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Contents

Are we consuming less to produce more? A case study towards sustainability of natural resources

MOHIT KUMAR KOLAY

The present paper examines, through productivity measures, whether the growth rate in consumption of natural resources is lower than the growth rate in output to assure their decoupling towards sustainability goal in the realm of natural resource accounting. Three factors, viz, the rate of consumption of i) iron ore, ii) energy, and iii) emission rate of carbon dioxide are considered here for two Indian steel companies for assessing natural factor productivity. The derived figure when combined with manpower productivity reflects the total factor productivity. This, in turn, is viewed in relation to the technology deployed to reflect their overall productivity achievements. Results show each factor—productivity, total, and overall productivity—of both companies are on an appreciating track, clearly confirming the sustainability of natural resources consumed.

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Introduction

Each and every country places tremendous importance on its economic growth and development. While the growth rate in GDP is considered as the success parameter of economic development, they often neglect to answer whether they are consuming unsustainable amount of earth's natural resources or not. This issue is rightly raised by the International Resource Panel, UN Environment Program (2019), particularly when 60 billion tonnes of construction minerals, ores, and industrial minerals, fossil fuels and biomass are extracted each year. Humans today extract and use around 50 per cent more natural resources compared to what was used 30 years ago. By 2050, humanity could devour an estimated 140 billion tonnes of natural resources, three times its current appetite, as estimated by the International Resource Panel. Barring the present temporary impact of lockdown due to COVID19 pandemic, India aims to become a 5 trillion-dollar economy from its current $2.8 trillion and move forward towards its path of self-reliance to achieve its target growth plan. But the vital question remains whether the growth of the economy will come at the cost of depleting the country's natural resources and causing harm to its environment, particularly when it reminds us that the average growth rate of gross state domestic product during 2005–15 for all the states of India was around 7–8 per cent, while 11 states registered a decline in their natural capital (Pandey, 2018).

To achieve India's targeted growth rate, iron and steel are the fulcrum that are expected to reinforce the country's infrastructure, and support the downstream industrial production as the output multiplier. Steel is really the prime that can potentially fuel the rise of India as a global manufacturing hub and give the much-needed boost to its

'Make in India' campaign. Steel industry contributes significantly towards employment generation for a country like India. As per the World Steel Association, globally, for every 2 jobs created in the steel industry, 13 more jobs are created across the supply chain. Indian steel sector employs 6 lakh people directly, and consequently, roughly 40 lakh people are employed indirectly in the total steel supply chain. India's GDP is very strongly correlated with its steel production to meet the country's demand for steel. In fact, this is evident from the similar growth patterns of India's GDP and its steel production, as national consumption of finished steel has increased from 6.5 MT in 1968 to 98.7 MT in 2018, while its GDP (at constant price, 2010) grew from USD 0.25 trillion in 1968 to USD 2.8 trillion today. During the last decade, Indian steel industry has witnessed a robust growth, production has gone up by 75 per cent, and demand up by 80 per cent. Per capita steel consumption has increased almost by 30 per cent during the last five years, but still India's current consumption figure of 74 kg per capita is far away from the world average of 225 kg of steel consumption per capita, and China's whooping figure of 590 kg per capita. To face the challenge, National Steel Policy has been adopted by the Government of India in 2017 to make its annual crude steel capacity reach 255 MT by 2030–31, with compound annual growth rate of 7.2 per cent. In fact, India has now overtaken Japan to become the world's second largest producer of crude steel, producing more than 100 MT each year (111 MT during 2018–19, up from 103 MT in 2017–18).

No doubt India needs to produce more steel to facilitate its growth process, but steel production is indeed capital intensive. An investment of Rs.7000 crores is needed for building up a tonne of steel making capacity from a green field scenario. Apart from the huge capital resources required for a resource constrained economy like India, the most relevant issue is the concern for sustainability of natural resources, as steel making consumes non-renewable natural resources like iron ore from iron ore mines, coal from collieries (in the form of coke produced from coal on heating in absence of air), limestone, dolomite, etc. which are added to the blast furnaces for production of hot metal for subsequent conversion into crude steel and finally for saleable steel output. What is paramount, is, we need to ensure that the economic growth needs to be decoupled from the rate of consumption of natural resources. We need to produce more (steel) with less consumption of natural resources. We nee to improve the rate of productivity of resources (including natural resources) faster than the economic growth rate. Productivity of natural resources consumed must be higher than the growth rate in output to enable the country to move towards sustainability.

As targeted in India's Steel Policy, to achieve 255 MT of steel pa by 2030–31, it would need a production target of 500 MT of iron ore. India's iron ore output is 230 MT now in 2019–20 and is estimated to grow 241 MT in 2028, with an average annual growth rate of 2 per cent during 2019–2028 period, greater than 0.9 per cent pa growth witnessed between 2009–2018. But the concern is the productivity of iron ore to ensure that its improvement in productivity must be higher than the growth rate in production of steel. The quality and quantity of reserves of iron ore available along with economic viability of mining will no doubt affect the productivity of iron ore to produce steel. Iron ore reserves in India is estimated at 22 billion T (6 per cent) out of the world's reserves of 370 billion T, per capita availability being just 22 T compared to Australia's 2000 T per capita. Again, the problem is accentuated by illegal mining in the ore-rich states of India. In another 40–50 years, India may be left with no or low-grade iron ore (Singh, 2012) and to make use of it for steel production will be the concern for productivity of iron ore, or possibly would require steel technology which would create environment havoc, with dry technology resulting in air pollution, and wet technology impacting water and land.

In addition to consumption of a natural resource like iron ore, another important non-renewable natural resource—coal—is required (in the form of coke) as fuel and also as the reducing agent for smelting iron ore in blast furnaces for production of hot metal to be converted to steel. India has the fifth largest coal reserves in the world with 319 billion T. However, only 10 per cent of it belongs to coking coal category, and less than 2 per cent is of prime coking coal variety. In fact, the ash content in Indian coal varies from 30 to 45 per cent and low calorific value, and that is the real concern for attaining productivity of coal towards hot metal and steel production. Unlike the Indian coal, imported coal is having a much lower ash content, between 10–20 per cent. As a result, India's coking coal import has been increasing over the years (increased to 44 MT from 39MT during the period from April 2017 to Feb 2018). Low ash coal, which is used in blast furnaces and basic oxygen furnaces of steel plants, is largely imported from Indonesia, Australia, and South Africa. However, the fluctuations in prices of imported coking coal eats into the profit margin of steel industry players. In addition to use of coking coal in blast furnaces, steel making being really energy intensive, consumes various forms of natural energy resources like oil, natural gas, and electric power generated from coal-based power plants. In fact, the world steel industry is the second biggest consumer of energy globally. Continuous technological improvements over the years at each and every stage of mining, blast furnace operations for hot metal, steel making, and subsequent rolling for finished steel production, the energy consumption per tonne of crude steel has reduced by almost 60 per cent from 1960 level to reach 20 giga joule (4.78 gcal) now per tonne of world crude steel production. Steel plants in India too have been able to reduce energy consumption by about 30 per cent in the new millennium (from 8 gcal/tcs in year 2000 to 5.8 gcal/tcs now on an average). However, they need to continue their consistent efforts to enhance energy productivity further, to match with the global standard towards sustainability of various forms of natural energy resources they consume.

Besides the consumption of non-renewable natural resources like iron ore, coal, and energy, steel making raises the environment protection issue. Steel as a product is environment friendly, it is 100 per cent recyclable and can be recycled infinitely to create new steel products, but steel making process causes emission of Green House Gases (GHG), particularly CO_2, wastes and dust. Total world production of 1.3 billion tonne of steel produces over 2 billion tonne of CO_2. The rising concentration of GHGs such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) alter the energy balance of the climate system and act as drivers of climate change. According to a Government of India report, India ranks fifth in aggregate GHG emissions in the world, behind USA, China, EU, and Russia in 2007. India's emission level stands at 2.07 billion tonne (1.58 tonne per capita) compared to China's highest emission level of 9.04 billion tonne (6.59 tonne per capita). The steel industry accounts for 6–8 per cent of global emission and is considered to be a hard to abate sector, since carbon is used as a reducing agent in the steel melting process and low carbon steel making technologies are yet to be commercialized. Keeping in view the Paris Agreement (2015) towards limiting of global warming to less than 2 degrees Celsius, and the GHG Protocol, the GHG emission per unit of GDP has been targeted to be reduced by 33–35 per cent by 2030 from the 2005 levels. The world steel, in its part, has also developed a global and regional life cycle inventory (LCI) database which provides "cradle-to-gate" environmental inputs and outputs to account for the use of various natural resources used in steel making for sustainable development, and emissions to air, water, and land to protect the environment, particularly to make CO_2 emission net zero by 2050.

The World Bank has been working on assessing the changing wealth of nations in terms of their stocks and flows of portfolio of assets (produced, natural, human, and net foreign assets) for long-term sustainability as against the traditional measure of GDP as the flow measure of previous year's economic activity. In India, the Government Accounting Standards Advisory Board (GASAB) has now come up with Natural Resource Accounting (NRA) as a promising tool for environmental impact assessment of projects involving the usage of land, water, forests, and mineral wealth for long-term health of the economy and its capacity to sustain growth. In such a context, it would be really interesting to examine how the two Indian steel giants, Steel Authority of India Limited (SAIL) in the public sector, and Tata Iron and Steel Company Limited (TATA) in the private sector are consuming the natural resources, *whether less for more*, enhancing productivity of natural resources higher than the growth rate in steel output. In the process of making steel for attaining economic growth, are they polluting the environment lower over the years or still more harmful for its people and the society.

Present Study: Two steel plants

TATA Steel (standalone unit only considered for the study, herein called Tata) belongs to the private sector as an integrated iron and steel plant, operating since 1907. It has been undertaking capacity expansion and modernization of its plant facilities over the years. Its current year annual output of saleable steel is 13 MT with a manpower strength of 32984. Its current year's sales figure is Rs. 70611 crores with net profit after tax of Rs. 16227 crores. Tata is considered as one of the lowest cost steel producers in the world. It has been adjudged the Steel Industry Leader globally on sustainability in Dow Jones Sustainability Index in 2018 with a top score of 100 percentile in Environmental Dimension. It has also received the distinction of being recognized as Sustainability Champion by the World Steel Association for the second year in a row.

SAIL, on the other hand, is an integrated iron and steel company (came up in 1973) in the public sector with five steel plants located at different places such as

Durgapur, Bhilai, and Rourkela (operating since 1962), Bokaro (operating since 1964), and Burnpur (merged with SAIL in 2006, operating earlier as Indian Iron and Steel Company Limited, IISCO, since 1922). Its current year annual output of saleable steel is 15.1 MT with a manpower strength of 72339. Its current year's sales figure is Rs. 66267 crores for which net profit earned after tax is Rs. 2179 crores (after being in red for three consecutive years). Being the pride of the nation, SAIL has been conferred one of the seven Maharatnas of the country's public sector enterprises.

Structure of the present study with its rationale

Amongst the different non-renewable natural resources used by the steel plants at the input front, the prime mineral is the iron ore, extracted from Hematite deposits obtained from their captive mines. Iron ore is smelted in blast furnaces for production of hot metal which is subsequently converted into crude steel and rolled thereafter into various flat and non-flat products as saleable steel output. The availability of iron ore deposits is no doubt limited, so also, its Fe content is a matter of concern along with associated cost of its mining. In pursuit of conservation of natural resources and achieving sustainability goal in the realm of natural resource accounting in the steel sector, the rate of consumption of iron ore is of prime importance. Productivity index of iron ore (in terms of tonne of crude steel output per 100 tonne of iron ore consumed) with the lowest productivity figure as the base of 100 has been used here to account for the trend in the effective consumption of iron ore over the study period.

Next important input for steel making is the use of coal, another non-renewable natural resource used as a reducing agent in blast furnaces and as fuel for supplying the necessary caloric value. But the ash content in the coal reserves available in India is quite high compared to imported coal. As a result, these two steel companies have started using higher percent of imported coal gradually in addition to coal raised from their captive collieries. Consumption rate of coal and coal productivity is no doubt important towards accounting for the use of such an important natural resource, but that needs detailed chemical composition analysis towards calorific value of various grades of coal obtained from captive mines, vis-à-vis imported from different countries. More importantly, as steel companies use many other forms of fuel such as oil and natural gas, besides electrical power purchased as well as produced in their captive power plants, it is important to account for the total energy consumption to start with, in line with the usual practice in the steel sector towards sustainability of different forms of non-renewable natural energy resources used. Productivity index of energy resources (in terms of tonne of crude steel output per 100 giga calories) with the lowest productivity as the base of 100 has been used here to account for effective consumption of various energy resources used together in steel making.

But while making steel, the process produces various wastes, dust, gases and smoke, of which the emission of Green House Gases in the form of carbon dioxide (CO_2) is a matter of great concern. Steel companies have been searching for ways and means to reduce GHG emission rate against set targets in terms of the Paris Agreement on Climate Change and GHG Protocol (2004). Unlike the two productivity measures of iron ore and energy as the positive factors of organizational performance (being directly proportional), performance of steel companies is negatively related (inversely proportional) to the quantum of CO_2 emission index (in terms of tonne of CO_2 emitted per tonne of crude steel) with the highest emission rate as the base of 100 by the process of steel making.

The above three factors (two positive factors in the form of productivity of iron ore and energy, and one negative factor in the form of CO_2 emission rate) on integration with suitable weightings, build up the natural factor productivity measure of steel companies (as presented in Figure 1) towards sustainability goal. The natural resources are no doubt activated and used by the manpower, the human capital of the organization, at each and every stage of iron and steel making to produce saleable output. Combining the manpower productivity index (in terms of saleable steel tonne per man) with the lowest figure as the base of 100 along with the natural factor productivity build up the total factor productivity of steel companies (as in the Figure 1). Then comes the level of technology adoption which is all pervasive in the production process of steel, not only in terms of rated plant capacity for the scale of output, but also to account for the latest process innovations and technological breakthroughs harnessed in the steel companies to govern each of three natural factor productivity as well as the manpower productivity. In fact, the two steel companies under study have been investing quite significantly over the years to modernize and innovate at each and every stage of steel making process, not only to produce more and more tonnage of saleable steel output of still better quality but also to continue to improve all the three natural factor productivity factors along with manpower productivity. This calls for examining the total factor productivity in relation to the level of technology adoption (in terms of investment-inflation adjusted per tonne of saleable steel) to measure the performance of steel companies, whether they are producing more for less or not (as reflected in Figure 1).

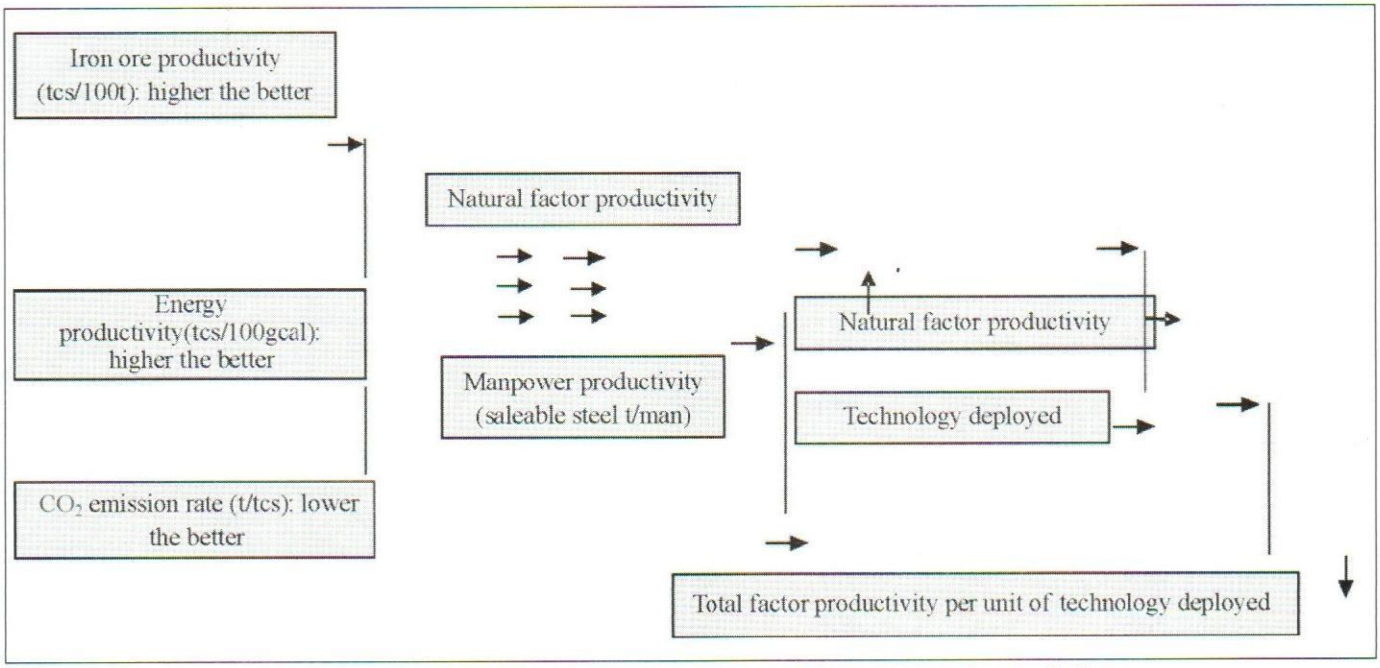


Figure 1: Natural Resources Accounting (NRA) framework for steel plants

Performance of two steel companies compared

The performance of the two steel companies have been examined here in the new millennium over a period last eighteen years from the year 2001 to 2019 (year ending 0n 31–03), taking data from their published annual accounts and other published reports. Tata steel with its basic plant being very old (1907) has been adding to their production capacity over the years, besides carrying out modernization and technological innovations over the years. In fact, its plant and technological infrastructures have gone up by more than ten times during the study period (as in Table 1).

Consequently, its crude steel production has been increased from 3.57 MT in 2001 to 13.23 MT in 2019 with an average growth rate of 15.05 per cent pa, so also its saleable steel output increased from 3.41 MT to 12.98 MT during the same period with an average growth rate of 15.57 per cent pa. SAIL, on the other hand, with comparatively much newer plants (1960s), started off with much higher initial capacity, its plant and technological infrastructures have gone up by four times during the study period. Consequently, its growth in steel production has been comparatively much lower compared to Tata, production of crude steel increased during the study period from 10.31 MT in 2001 to 16.27 MT with an average growth rate of 3.21 per cent pa, and saleable steel increased from 9.41 MT to 15.07 MT with growth rate of 3.34 per cent pa on an average. On the manpower front, both the steel companies have been trying to reduce their roll in permanent manpower. SAIL being in the public sector with relatively much heavier manpower burden has been able to reduce the same by 54 per cent during the study period (reducing from a staggering figure of 157 to 72 thousand now). Tata, on the other hand, has been able to reduce its manpower by 32 per cent (from 49 to 33 thousand now), as presented in Table 1.

At the input front, iron ore productivity index of SAIL has been varying within a comparatively closer range with marginally higher average of 135, as against Tata's having wider variation with an average index of 127 (56.7 tonne of crude steel output on an average for SAIL, compared to 53.0 tonne of Tata per 100 tonne of iron ore used), as presented in Figure 2. Differential Fe content in iron ore used may possibly be the reason for the difference in their average iron ore productivity, however, overall trend in iron ore productivity indices presents an improving trend for

Table 1: Trend of operational parameters of TATA and SAIL

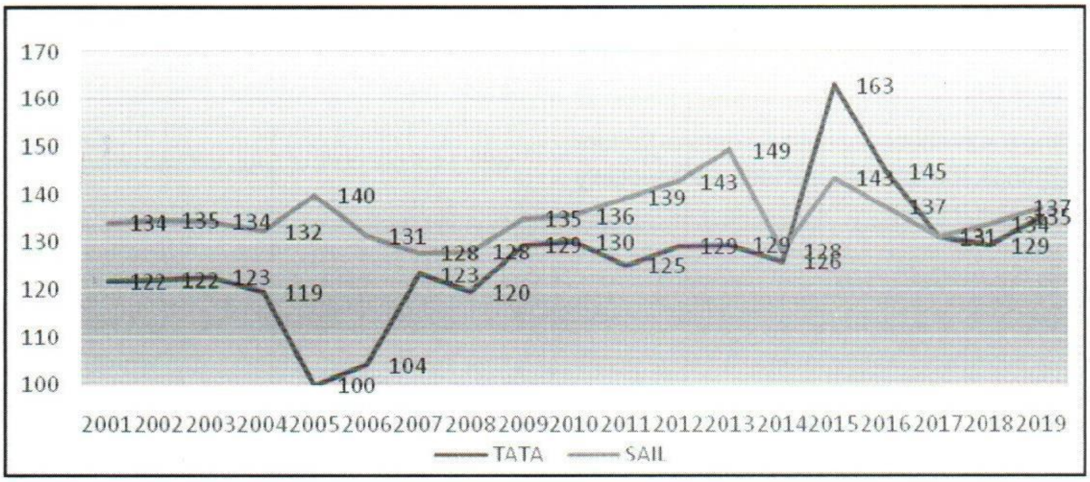
Year ended 31–03	Crude Steel (000T)		Saleable Steel (000T)		Total Manpower		Net Block Rs. Cr.	
	TATA	SAIL	TATA	SAIL	TATA	SAIL	TATA	SAIL
2001	3566	10306	3413	9410	48821	156719	7538	15177
2002	3749	10467	3596	9464	46234	147601	7543	14798
2003	4098	11087	3975	10086	43248	137496	7544	14036
2004	4224	11828	4076	10727	42511	131910	7558	13154
2005	4104	11827	4074	10651	39648	126857	9112	12485
2006	4731	13177	4551	11624	38182	138211	9865	12162
2007	5046	13194	4929	12127	37205	132973	11041	11598
2008	5014	13649	4858	12531	35870	128804	12624	11571
2009	5646	13148	5375	12052	34918	122043	14482	12305
2010	6564	13199	6439	12632	34101	116950	16006	13615
2011	6855	13453	6691	12887	34912	110794	17417	15083
2012	7132	13350	6970	12400	35793	106004	27413	17127
2013	8130	13417	7941	12385	35905	101878	33597	16177
2014	9155	13579	8931	12880	36199	97897	42795	26771
2015	9331	13908	9073	12842	36957	93352	48285	36169
2016	9960	14279	9698	12381	35439	88655	52410	45926
2017	11683	14496	11351	13867	34989	82934	78731	50285
2018	12482	15020	12237	14074	34072	76870	77402	58612
2019	13228	16266	12980	15069	32984	72339	77018	61359

(*Sources:* Published Annual Accounts of Tata Steel and SAIL, accessed from the internet)

both—improvement rate in iron ore productivity of Tata (slope of 1.45) being much higher compared to that of SAIL (slope of 0.23).

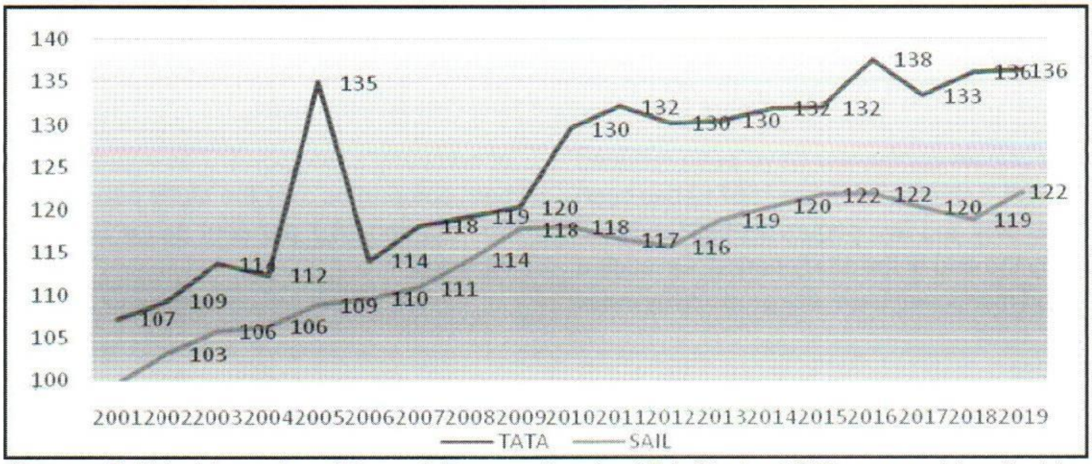
On the energy front, Tata's productivity level has been consistently higher compared to that of SAIL, with the average productivity index 125 of Tata being almost 10 per cent higher compared to SAIL's figure of 114 (i.e., 15.8 tonne of crude steel output of Tata on an average compared to 14.4 tonne of SAIL per 100 gcal of energy used), as presented in Figure 3. Overall trend in energy productivity index presents an improving trend for both, however, the improvement rate of Tata is higher (slope of 1.57) compared to SAIL (slope of 1.15). Improving trend in energy productivity demonstrates continuous efforts made by both companies to reach the world's average of overall energy consumption rate of 4.78 gcal per tonne of crude steel, i.e., energy productivity of 21 tonne of crude steel output per 100 gcal, in the near future.

As regards CO_2 emission, both companies have been making consistent efforts to reduce the same. Tata has been able to reduce its emission level by 19.86 per cent as against SAIL's figure of reduction of 18.41 per cent during the study period. As shown in the emission control index of Figure 4, emission level of Tata has been



(Sources: Published Annual Accounts of Tata Steel and SAIL, accessed from the internet)

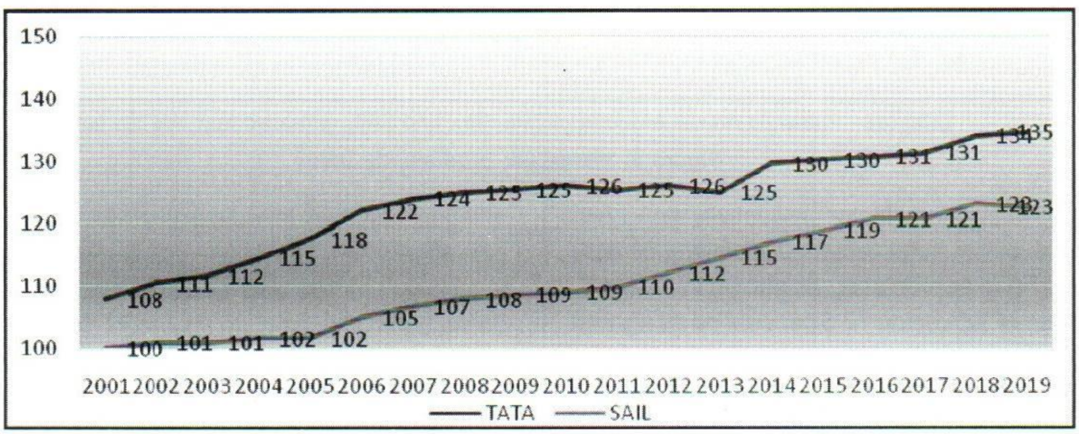
Figure 2: Iron ore productivity index



(Sources: Published Accounts and Energy & Economy Reports of Tata Steel and SAIL, accessed from the internet)

Figure 3: Energy productivity index

consistently lower (having 10.5 per cent lower average) than that of SAIL. Taking the current year's crude steel production, these two steel companies have added together 73 million tonnes (42 MT by SAIL @2.57t per tcs, and 31 MT by Tata @2.34t per tcs) of CO_2 to India's environment during the year ended 2019. It is indeed



(*Sources:* Published Annual Accounts of Tata Steel and SAIL, accessed from the internet).

Figure 4: CO_2 emission control index

imperative to innovate and work out still more with low carbon steel technology to reach the set target of net zero CO_2 emission by 2050.

Aggregating the productivity of three natural factors with equal weightings, the total natural factor productivity indices for both companies are shown in Figure 5. Total natural productivity scores of both companies are on the appreciating track. Tata's improvement rate being higher, 20.5 per cent during the study period with an average of 125, compared with 14.4 per cent of SAIL with an average of 120.

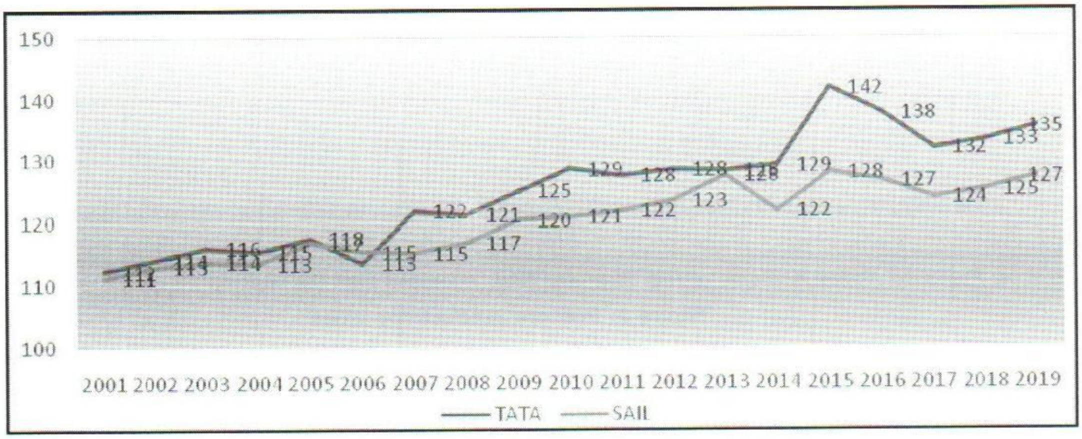
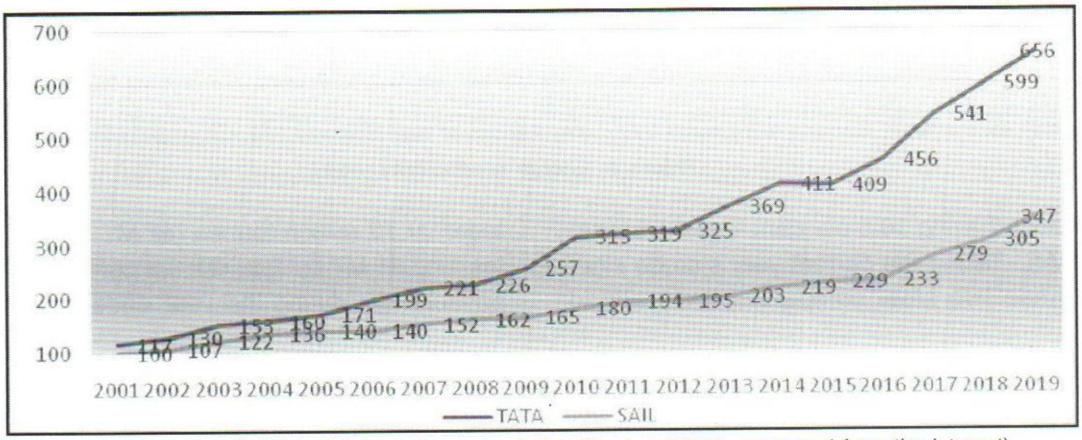


Figure 5: Total natural factor productivity index

Manpower of both companies have been reduced over the years. SAIL's staggering figure 156719 has been reduced by 54 per cent and Tata's figure of 48821 reduced by 32 per cent by the end of the study period. On such a gradually reduced manpower base, the productivity index of company's manpower has improved significantly for both companies over the study period, 25.6 per cent pa for Tata and 13.7 per cent pa for SAIL as presented in Figure 6.



(*Sources:* Published Annual Accounts of Tata Steel and SAIL, accessed from the internet).

Figure 6: Manpower productivity index

Integrating total natural factor productivity along with manpower productivity, total factor productivity of both companies has been appreciating as shown in Figure 7, improvement rate of Tata being 13.6 per cent pa as against SAIL's 6.9 per cent pa.

The level of technology deployed (in terms of net block) has increased by 10 times for Tata and 4 times for SAIL during the study period as given in Table 1. The inflation adjusted investment of Rs.10000 per tonne of saleable steel has been considered as the level of technology index, duly converted in relative terms with base as 100. Now, to account for the company's performance towards managing its total resources, weighing the total factor productivity against the level of technology index, the relative total productivity per unit of technology deployed has been assessed as presented in

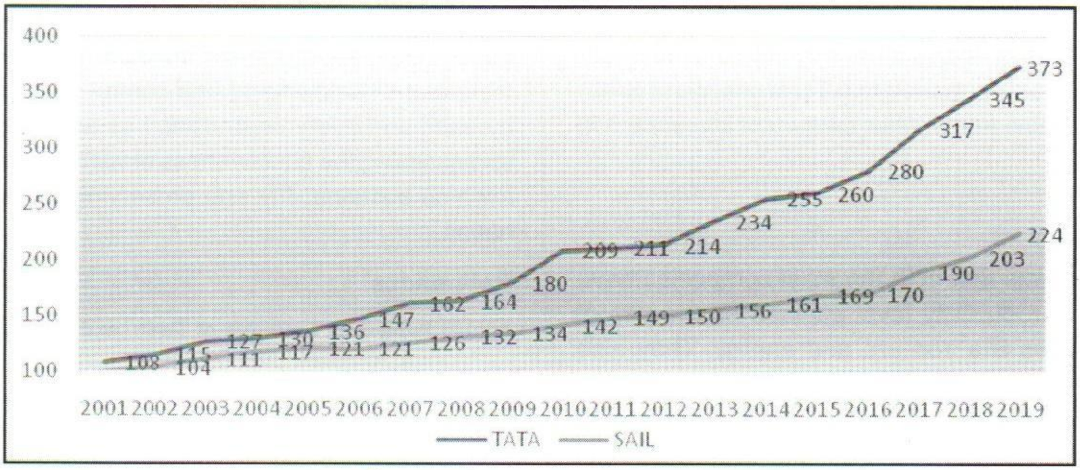
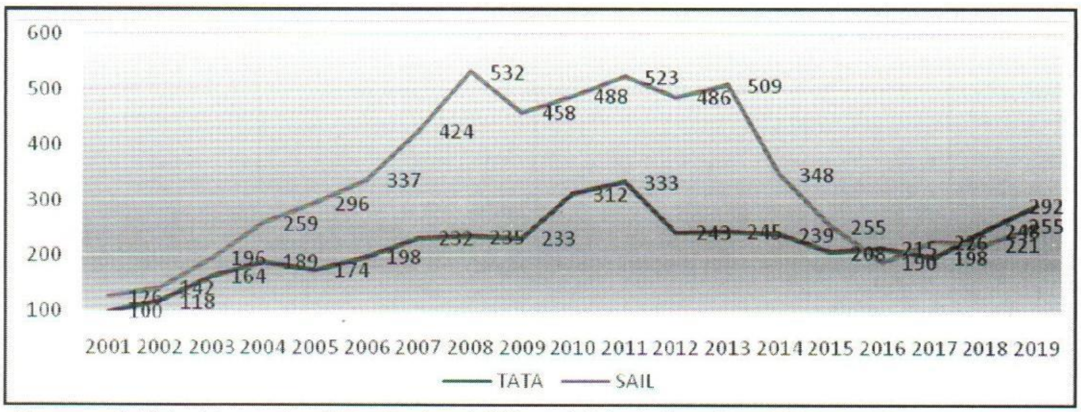


Figure 7: Total factor productivity index

Figure 8. With much higher growth in technology index, Tata's average relative total productivity per unit of technology deployed is lower at 220, compared to 330 of SAIL. However, Tata has been able to realize the gains from higher technology index over the years. As a result, the improvement rate in relative total productivity per unit of technology for Tata has been higher over the years, 10.7 per cent pa as compared to 5.7 per cent pa of SAIL.



(*Sources:* Published Accounts of Tata Steel and SAIL, and Price Indices from RBI Bulletin from the internet)

Figure 8: Total productivity index per unit of technology

The above performance analysis shows that both the steel companies have been enhancing their respective productivity levels over the years for the use of both natural resources, iron ore and energy, with the improvement rate in productivity of Tata being higher than SAIL (as reflected by the slope of the respective productivity indices figures, 1.45 of Tata as against 0.23 of SAIL for iron ore, and 1.57 of Tata as against 1.15 of SAIL for energy). On CO_2 emission front, both companies have reduced the emissions rate; Tata reduced by 20 per cent during the study period whereas SAIL reduced it by 18 per cent. Taking into account all three natural factors, the total natural productivity indices have improved for both the companies; improvement being higher for Tata, 20.5 per cent of Tata during the study period compared to 14.4 per cent of SAIL. Both companies have improved their manpower productivity; 25.6 per cent pa by Tata compared to 13.7 per cent pa by SAIL. Considering productivity of total natural factors along with productivity of manpower, total factor productivity has been enhanced by both companies; 13.6 per cent pa improvement by Tata and 6.9 per cent pa by SAIL. When total factor productivity is weighed per unit of technology index where net block have been increased 10 times by Tata as compared to 4 times by SAIL, the average productivity level of SAIL shows almost 50 per cent more during the study period compared to Tata (average index of 330 of SAIL compared to 220 of Tata). Both companies have improved their relative productivity figures over time, however, the average improvement rate of Tata is almost double of SAIL (10.7 per cent pa for Tata compared to 5.7 per cent pa of SAIL) showing their gains from higher amount of investment in technology.

Conclusions

The study confirms that both the steel companies have enhanced the productivity level attained on the use of natural resources like iron ore and energy. They also reduced the CO_2 emission rates to protect the environment. Both Tata and SAIL have been marching ahead with more and more steel production to meet the country's target economic growth plan, but at the same time, they have always ensured that they produced more than they have consumed the natural resources or harmed the environment. The growth rate in productivity attained on each factor is testimony to that confirmation, economic growth has been really decoupled from the rate of natural resource consumption. External reporting apart, as required by environment policy planning bodies and the government, the suggested framework can be used as an internal tool for planning and control which can be used by each and every organization as an ongoing exercise for assessing the effectiveness of various resources used towards sustainability and preserving the wealth of the nation.

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All our efforts to defeat poverty and pursue sustainable development will be in vain if environmental degradation and natural resource depletion continue unabated.

– Kofi Annan

Challenges of Water Resources Management and Water Allocation in India

M. DINESH KUMAR, M.V.K. SIVAMOHAN AND NITIN BASSI

With growing water scarcity, the priorities for the water agencies of the country have broadened from mere water development to encompass water allocation and water resources management. But the line agencies responsible for water resources and services management lack the capacity to meet the changing needs and priorities of the sector. Building institutional capacity warrants primarily the following: i] framing the right kind of water policies; ii] crafting the right kind of rules and regulations, institutions and instruments; and, iii] fostering the needed organizational changes among the agencies concerned with water allocation and sustainable water resources management.

The article highlights three sets of key issues and challenges facing water resources management and water allocation in India from an institutional perspective. They are: a] team building of professionals with multi-disciplinary skills, to provide research and expert inputs for policy formulation, institutional design and design of economic instruments; b] mobilizing resources and skills for creating new organizations including development of local institutions, and restructuring wherever needed; and, c] augmenting the overall strength of technical staff in various departments engaged in water resources management and water-related services.

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1. Introduction

The water management challenges in India are far many. As of 2011, nearly 88 per cent of the households have access to improved water supplies, with the percentage being below 84 per cent in rural areas. But, as per the data from 2011 census, the number of "tap" connections (within the household premises), which is indicative of good access to safe water, was as low as 14 per cent in rural areas. In urban areas, however, the number of tap connections within the household premises was 54 per cent, but the service quality is very poor. In the 35 metros of India, water supply is available only for a few hours in a day. As regards tariff, nearly 62 per cent of the urban consumers in metros having more than one million population have metered connections, the percentage being 50 per cent in smaller towns. In many cities and towns, the domestic connections are not metered at all. In order to achieve 100 per cent water security, India has to make significant progress in terms of strengthening the sector agencies.

Though India boasts of having the largest irrigated area in the world with 85.78 million hectares (m. ha) in 2006–07 as gross irrigated area from all sources, 59 per cent of this area is irrigated with groundwater (in terms of net area irrigated by wells). The groundwater pumping is to the tune of 249 billion cubic meters (BCM) as of 2017 as per official estimates (Government of India, 2019). But, attempts for direct control of its development and use through state regulations or water rights, or indirect control through the use of economic instruments such as electricity pricing, energy rationing or groundwater tax are not visible on a large-scale, while some states such as Gujarat, Odisha and West Bengal have recently made some progress in metering and pro rata pricing of electricity in farm sector (Kumar, 2016).

Though there has been steady growth in net surface irrigated area in the country over the past five to six decades (Planning Commission, 2008; Kumar *et al.*, 2009), the inadequacies with respect to management of water distribution and delivery systems, and pricing of irrigation water are amply visible (Kumar and Singh, 2001; Kumar, 2010).

India is facing a major water crisis (Amarasinghe *et al.*, 2008; Kumar, 2010). For instance, Kumar (2010) projected the gap between water demand from various competitive-use sectors and supply to be around 26.2 m. ha m (i.e., 262 BCM) by the year 2025. There is increasing evidence to suggest that growing water insecurity would check the advancements in social development and economic growth (Shah and Kumar, 2008). There is now a growing consensus in the development fraternity that capacity development of water sector institutions is one of the important drivers for water security (see for instance, Sullivan, 2002; Laurence *et al.*, 2003; Grey and Sadoff, 2007; Lemos *et al.*, 2016). Further, in the face of current economic, environmental, political, and social conditions, developing state and societal capacities to design and implement strategies for improvement in water resources sector is considered critical for achieving the objectives of sustainable development (Downs, 2001; Folke *et al.*, 2002).

UNDP (2009) defines capacity development as the "process through which individuals, organizations and societies obtain, strengthen and maintain the capabilities to set and achieve their own development objectives over time". To put in simple words, if capacity is the means to plan and achieve, then capacity development describes the means to achieve the ends. Brown (2004) described three mutually interactive spheres of capacity building, namely: a) Human resource development; b) Organizational change; and c) Directive reforms. These spheres have well-known capacity development interventions but the relationships within and between these spheres are important for continually improving current capacity. Further, UNDP (2009) points four core issues that seem to have the greatest influence on capacity development, and they include: a) Institutional arrangements, b) Leadership, c) Knowledge, and d) Accountability.

The two key areas where capacity building is required are water resources development and water allocation across, and within sectors. The article discusses the issues and challenges facing the water sector institutions in performing water resources management and water allocation functions from an institutional perspective.

2. Capacity Building Issues in Water Resources Sector

In developing world, capacity building has become a buzz word for sustainable development of water sector. But the approaches to enhance capacity suffer from numerous conceptual and operational constraints (Biswas, 1996). Experiences show that institutional weakness and malfunctions are a major cause of ineffective and unsustainable water services in developing countries like India (World Bank 2004; Saleth, 2005; TERI, 2006). For instance, the existing institutions in India's water sector are designed and equipped to appropriate and develop, and not to allocate and manage the resources. They lack institutional capabilities to efficiently allocate water amongst competing uses such as irrigation, rural domestic uses, industrial uses and municipal uses or to alter the socio-economic systems to manage the demand for water. A major reason is the lack of property rights in water for different sectors in volumetric terms and users within each sector, and inefficient pricing of water in different sectors (and Singh, 2001; Saleth, 1997; Kumar, 2010). Insufficient exposure to the concept of "allocation efficiency" and lack of adequate knowledge about productivity of water in various uses and its links with market instruments such as property rights is a major issue.

With growing water scarcity, the priority of water bureaucracies has shifted from water resources development to water allocation and water resources management (Saleth and Dinar, 2004). The need to better manage overall water resources coherently and to facilitate allocation of water among all users requires an expansion and integration of national water resources planning. Thus, the major institutional challenges are to develop policies, rules, organizations and management skills which address both, i.e., water resources management and water allocation needs, simultaneously (Hamdy *et al.*, 1998). While addressing these challenges, the right processes have to be followed. Figure 1 presents the framework for capacity building in water resource sector which is discussed in detail in the subsequent sections.

3. Developing Policies, Rules and Organizations for Water Resources Management

3.1. Policies and Rules

The task of framing of policies and rules on water resources management requires comprehensive and integrated

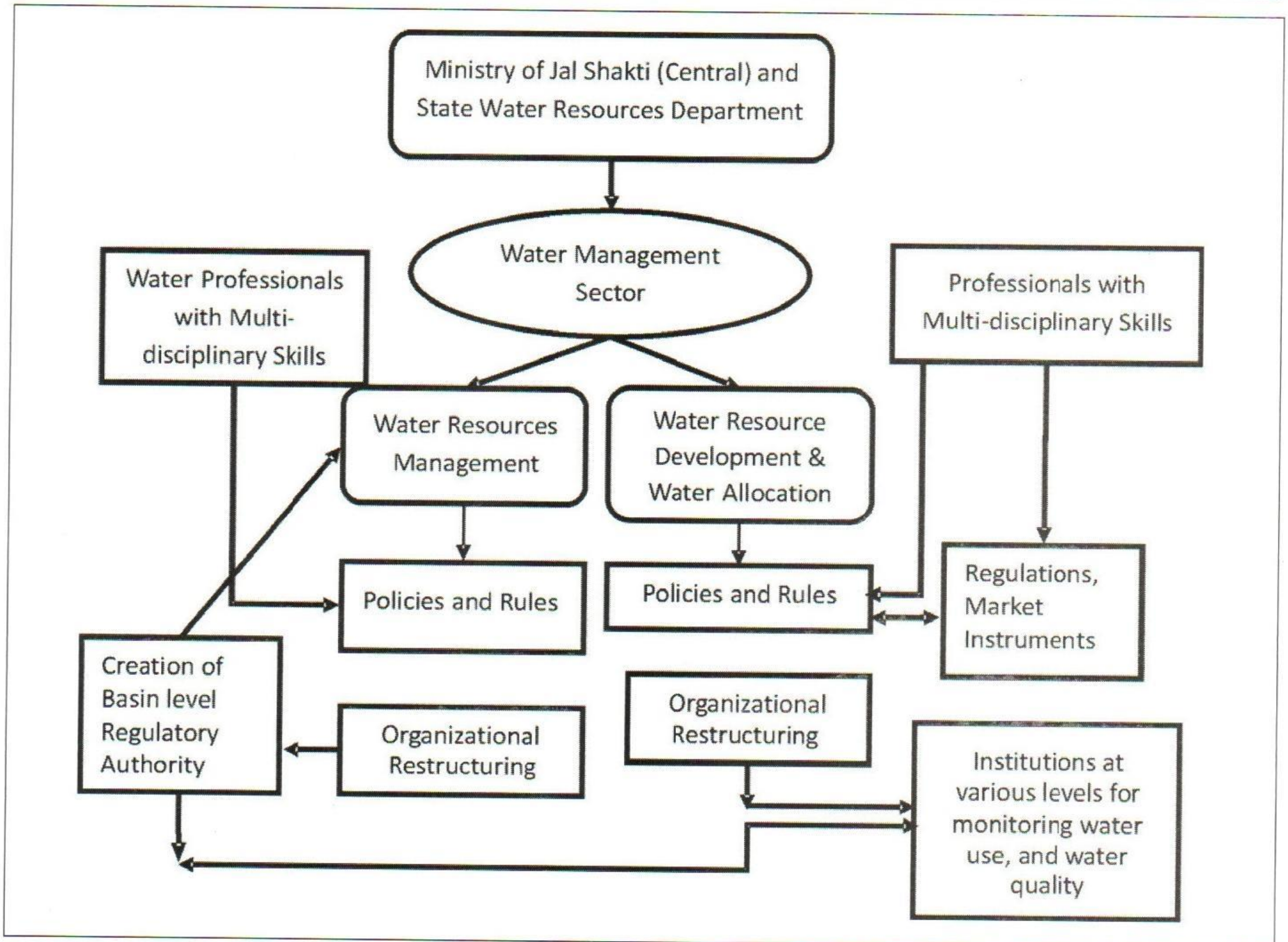

Figure 1: Framework for Capacity Building in Water Resources Sector
(*Source:* Authors' own contribution)

understanding of the hydrological, social, economic, ecological, and institutional issues (Kumar, 2018a). They concern: the interactions between various physical systems influencing water availability at the level of river basins; various socio-economic systems affecting water demand; interaction between ecological system and hydrological system (Kassem, 1993; Klomp, 1993); factors influencing the economics of management actions, including the cost of various resource management interventions and value of the resource (Rosegrant *et al.*, 2000); the factors influencing the transaction cost in resource management (McCann *et al.*, 2005); and institutional design principles (Huntjens *et al.*, 2012).

This implies that there is a need for skilled professionals in the field of agricultural sciences, public health, basin and catchment hydrology; environmental hydrology; hydro-chemistry, water resources economics; natural resource accounting; institution building; organizational behaviour and institutional economics, with particular reference to water resources management. Barring the first two, the skills in other disciplines are not readily available. Let us take the example of catchment hydrology, which is the least understood when talked about water harvesting. Smaller catchments of most of the rivers in india are not gauged for stream flows and siltation. Scale problems in hydrology are well documented (Sivapalan and Kalma, 1995; Wood *et al.*, 1990). Applying rainfall-runoff relationship of large river basins to small catchments would result in over-estimation of runoff (Kumar *et al.*, 2006). In the absence of knowledge about catchment hydrology and effective storage capacity of structures, cost calculations of water harvesting structures become superfluous as well (Kumar *et al.*, 2006).

3.2. Organizations for Water Resources Management

The agencies engaged in water resources development such as the irrigation department, water supply department, and minor irrigation (groundwater) department are entrusted with the mandate of water resources planning and water resource management. Hence, there is a multiplicity of functions with which these line agencies are engaged in. This is against the principle of institutional design for sound water resources and water-related environmental resource management (Frederiksen, 1998). These agencies have no special incentive to manage water resources, including water quality management. This is because their performance is evaluated in relation to the amount of water they supply, coverage in terms of area irrigated or number of habitations covered, and the revenue collected from the same, and not in terms of the water available for environmental flows in the basin, or the quality of water in the river or the aquifer. As a result, they compete with each other and over-appropriate water from the basin. These objectives are in conflict with the larger objective of water resources management. This inherent trade off, which is because of defective institutional design, reduces the effectiveness of line agencies.

Problems are also with organizational structure of line agencies. There is an explicit relationship between organizational structure and functions (Kumar *et al.*, 2000). While structure does not guarantee performance, inappropriate structure is a virtual guarantee for sub-standard performance (Hunter District Water Board, 1982). As Kumar *et al.* (2000) notes in the context of Sabarmati river basin, the governance is based on ad hoc norms of minimum design command area—for Circles, Divisions and Sub-divisions—rather than hydrologic system considerations such as basin boundaries. The net result is that different Circles are looking after the irrigation schemes falling in one sub-basin. Similarly, the same Circle is looking after irrigation schemes in different sub-basins. The fact that there is no coordination among different circles of irrigation department working in the same sub-basin greatly reduces the ability to take into account the hydrological system considerations in planning water systems leading to piecemeal approach to water development. The consequence is that water in the basin gets over-appropriated (Kumar, 2006).

The minor irrigation wings of irrigation department undertaking large-scale construction of small water harvesting structures in the upper catchments of large reservoirs in states such as Rajasthan, Gujarat and Madhya Pradesh are examples of a malfunction, which happens because of lack of coordination between various wings within the irrigation department. As Kumar (2006) noted in the context of Sabarmati river basin, in addition to the major and medium irrigation schemes, several hundreds of small structures were built throughout the basin. They are basically meant to serve as water harvesting and groundwater recharge schemes. Though the storage and recharge capacity of individual schemes is very low, put together they make a significant reduction in the flow of available surface water, which could be tapped by other schemes. But the planning of large reservoir and diversions schemes in the basin do not consider the impact made by these small structures, which were planned and built by the Panchayat Irrigation Circle based on demand from villages.

Lack of ability to integrate knowledge from disciplines other than hydrology into water resource planning compounds the problem. For instance, the irrigation departments, which deal with the bulk of developed water resources in the country, do not have professionals qualified in environmental hydrology, hydrochemistry, agricultural sciences and irrigation economics. Often, observations are made by experts to change the curriculum of technical degree courses. Training institutions, by far, also lack an integrated approach. This is considered to be one of the reasons for the inefficient performance of irrigation sector in the country even after huge investments both by government and international agencies (roughly Rs. 167,384 crore on developing major and medium irrigation schemes alone till the tenth five-year plan).

The absence of a regulatory authority for water resources at the level of river basin or at the state level is another major issue. The very fact is that the economic costs as induced by over-appropriation of water in the basin, owing to reduction in stream-flows for ecological and social uses, represent major negative externalities on the society. These costs can be treated as opportunity costs of not having institutions for regulating basin-wide water development (Kumar, 2010). But such approaches of creating regulatory institutions are criticized by some scholars for the "huge" transaction costs involved (see for instance, Shah and van Koppen, 2006). There is little realization of the fact that as water becomes scarcer, such opportunity costs tend to exceed the transaction cost of creating them (Saleth and Dinar, 1999; Kumar, 2010).

4. Developing Policies, Rules and Organizations for Water Allocation

4.1. Policies and Rules for Water Allocation

Developing policies for water allocation calls for a good understanding of the factors influencing: the demand for water and the human behaviour with regard to water use, including pollution, or the factors that are capable of altering the socio-economic systems determining the demands for water. For instance, professionals having a sound understanding of physical (agro-meteorological and climatic), socio-economic, institutional and cultural factors influencing the water demands are required for inter-sectoral water allocation in a water-scarce river basin.

The institutions for water allocation can include state regulations as well as market instruments such as property rights in water, water tax and pollution tax, water and electricity pricing etc. Deciding the nature of regulations (whether "top down" or enabling and location specific) and designing effective regulations require sound understanding of laws, and the complex social systems and cultures apart from the characteristics of the water-related ecological system which is to be co-managed with water.

Designing the market-based instruments requires thorough understanding of environmental economics, institutional economics and agricultural economics along with technical aspects of water productivity, water use efficiency and water quality management. For instance, designing a farm power tariff regime, which is not only capable of producing the desired outcomes of efficient groundwater use in agriculture but also remaining to be economically viable for farmers and financially viable for state electricity boards, would need good understanding of economics of energy production and supply on the one hand and farming conditions and water use efficiency requirements on the other.

Therefore, doing such analysis would require multi-disciplinary knowledge and skills that are mostly not found with civil engineers and electrical engineers, who manage water and electricity supply agencies, respectively. This stops them from being advocates of policy instruments. More importantly, there are political and social challenges facing application of these instruments. For instance, government move for power tariff reform is often fraught with resistance from farming lobby and parties in the opposition (Kumar, 2018b). Similarly, some civil society groups, which promote popular approaches such as community management of water, decentralized water governance, etc., are also lobbying against the introduction of market-based instruments (Kumar and Pandit, 2018).

4.2. Agencies for Water Allocation

There is very little understanding about the nature of organizations which are required for ensuring water allocation that is sustainable, equitable and efficient (Roa-García, 2014). This is particularly true in the case of groundwater, given the fact that the resource boundaries are not well defined; there are hundreds of thousands of users accessing water from the same source, who are scattered over large geographical areas; and who are not connected to public systems such as power distribution network as the case with diesel pump owners.

When problems are of a great magnitude affecting large geographical areas, the government agencies have questionable ability to create such institutions. The current experience of government agencies and NGOs is mostly with building local organizations, which operate at the level of villages and watersheds, such as the water users' associations and watershed management committees. These organizations are very limited in numbers. There are also problems with the quality of these organizations, which were created to perform certain management functions. The focus of the agencies which are promoting these organizations often is on achieving the targets, rather than facilitating the processes which are essential for institution building (Farrington *et al.*, 1999).

More importantly, research has already shown that most of these institutions are ineffective in internalizing some of the negative externalities (both physical and socio-economic) the local management actions are subjected to. Institutions are required at various levels, and they need to be integrated at the level of basins or aquifers (Kumar, 2000; Kumar, 2007). However, such institutions are absent both at the local level as well as at the basin and aquifer levels.

Private sector participation in carrying out various functions is being suggested as a paradigm shift to improve the performance of water resources agencies. There are evidence from many parts of the world to the effect that private sector participation leads to improved performance of public sector institutions in water (Biswas and Tortajada, 2003). But there is growing scepticism among civil society organizations in India about the impact of private sector involvement in water management including water resources management and provision of water related services. Political decisions to involve private sector in water management are often unpopular and face staunch resistance from opposition parties and the public alike. However, informal private water markets have emerged in a big way in agriculture (Srivastava *et al.,* 2009; Manjunatha, 2016) as well in urban sector (Venkatachalam, 2015; Vij *et al.,* 2019), in response to growing scarcity. While they generate some benefits, they also induce large social cost in terms of over-exploitation of groundwater, provision of poor-quality drinking water, etc. The civil society organizations voicing concern over private sector participation are silent on the informal water markets.

5. Human Resources Development

As per one estimate, the water economy in India is growing at an annual rate of 18 per cent and the services in the sector are worth Rs 60,000 crore per annum. It is predicted that at least one million job opportunities are likely to be created in water sector in India, as the demand has picked up for wastewater treatment plants and desalinization plants apart from the engineering and design of water applications (Source: Deccan Chronicle, May 6, 2011).

The importance of human resource development in managing India's water economy cannot be over-stated. This is quite clear from the fact that during pre-Independence era, the British, who wanted to run irrigation as a business rather than as a welfare measure, started the first irrigation training college in India. One major issue related to human resource development is the availability of adequate staff in water utilities. Over the years, the irrigation departments across states in India union, which is the largest employer of civil engineers, have been reducing their technical staff strength. While the old staff retires, they are not replaced by newly recruited staff. Many state water departments (irrigation and water supply) have progressively stopped new recruitment. One of the underlying assumptions seems to be that since no new additions to the infrastructure, particularly for irrigation, lesser number of staff should be able to manage the routine works of maintenance and repairs, thereby, improving the staff efficiency. In fact, with both central and state governments allocating substantial amount of money for undertaking land and water management works under the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) in a decentralized format, there is a huge demand for trained technical staff to plan, design and execute such works.

While "staff efficiency" is considered to be a major indicator of management performance in various related services, the problem is with the narrow technical criterion being used to evaluate staff efficiency without giving any due consideration to the quality of the service. In the context of irrigation, it is the area irrigated per staff, and in case of public water supply, it is the number of water (tap) connections per staff. Now, in the context of irrigation, what is equally important as the area irrigated is the quality, which comprises adequacy, reliability and timing. In the context of public water supply, the per capita supply levels (litre per day), quality of the water supplied, duration, reliability and timing are as important as the number of connections. Obviously, a water supply system, which provides 24 X 7 water supply, would require much more staff to run and manage the system than one which provides supply for limited hours a day.

Analysis of data on performance of urban water utilities belonging to different categories, viz., Metros, Class I and Class II cities, available from NIUA (2005), shows that the metros, which show remarkably higher physical performance, are characterized by better staffing (in terms of number of staff per 1000 people) and staff composition, and greater investment for operation and maintenance. Therefore, if we take the metros as the benchmark for performance improvements of urban water utilities, the smaller towns will need to be equipped with more staff. But, the tragedy of not evolving composite criterion for measuring staff efficiency is that as the tendency to reduce the staff continues, the services deteriorate to such an extent that the "staff efficiency" itself lowers.

In the context of public irrigation, Uphoff (1991) had pointed out that management of irrigation functions requires many more professional staff than that is required to plan and execute the projects. This is particularly in view of the fact that irrigation development is no longer restricted to just planning and building infrastructure, but encompasses water allocation decisions, its execution, training of lower level staff of irrigation management concepts, undertaking system operation, and regular maintenance (Kumar *et al.*, 2000). In the context of drinking water supply, the challenge today is more of water quality monitoring for checking water contamination, carrying out regular checks for theft and pipeline leakage, installation of water metres and regular reading, operation & maintenance of the water supply system, and water quality management (IRAP and UNICEF, 2019). All these require

TABLE 1: Comparison of Average Physical, Financial and Economic Performance and Human Resource Profile of Utilities under Different Classes

Sr. No	Variable	Performance Indicators	Status in		
			Metros	Class I	Class II
1	**O & M Charges**	Per capita WS (lpcd)	160.2	111.9	86.3
		O & M cost per MLD (lac Rs)	8.9	6.9	10.1
		O & M cost per capita (Rs)	518.6	274.9	322.3
2	**Water Supply (%)**	% of population covered	94.6	90.2	89.2
		Demand achieved (%)	96.4	78.4	78.6
		Supply gap (%)	3.6	21.6	21.4
3	**Sanitation**	Population covered (%)	51.7	47.4	51.1
		Area covered (%)	45.4	40.7	48.5
4	**Solid Waste Management**	Waste generated (ton/annum)	1598.0	136.4	27.2
		% of waste collection	88.9	86.3	79.5
5	**Staff**	Water supply staff for 1000 people	0.73	0.55	0.63
		Staff per 1000 connection	12.4	9.3	8.8
		Technical staff in WS (% of total)	21.8	19.1	17.2
6	**Metered Connections**	Total tap connections	4667326	3303030	608735
		% of metering	51.9	40.9	33.6
7	**UFW**	Water Supplied (MLD)	603.7	45.1	7.7
		UFW in %	22.9	13.1	10.9
8	**Treated water**	No. of Treatment plants	92	255	78
		% of towns covered	95.5	62.1	47.7

(*Source:* Analysis based on data from NIUA,2005).

not only more engineering staff, but with additional skills and capabilities in water quality management and water treatment.

The country's ability to deal with future water challenges can be seriously doubted if one looks at the number of engineers that all the institutions in India put together produce. According to one estimate, India produces nearly 200 engineers per million population, against 750 in the United States, and 500 in China (Source: study by Duke University, North Carolina, USA). There are no break-ups available to arrive at a correct estimate of the actual number of civil engineers produced. But some recent estimates show that nearly 35 per cent of India's graduate engineers are from information technology (IT) and a further significant fraction of the civil engineers move to IT sector in search of greener pastures.

If we make a reasonable assumption that one out of every four remaining engineer is from civil engineering (with the rest belonging to the other core engineering branches such as mechanical engineering, chemical engineering and electrical engineering), a one million population has a total of nearly 32 civil engineers. This is an abysmally low figure, if we look at the requirements in India's rural and urban areas. Again, a large number of them today work in the construction industry, building roads, bridges, flyovers, railways and airports. Let us assume that fifty percent of them are engaged in construction industries, thereby making the number actually available for water sector to be 16.

India has nearly 5.95 lakh inhabited villages. The fact is that every village has some provision for water supply by a publicly managed system, or if absent, is expected to have one in the near future. These water supply systems can be bore well/tube well/open well with overhead tanks, distribution system and stand-post, or a few hand-pumps, or distribution system of a regional water supply system. The communities are not equipped to manage these systems on their own, though there are a few fine examples of community management in certain pockets in the country. We can reasonably assume that a water supply engineer caters to a population of 10,000 people, with one or two technicians under him/her for undertaking the tasks of repair and maintenance. This means, we need at least 1.2 lakh engineers with approximately one for a group of two villages.

Similarly, for public surface irrigation, which cover a net area of around 25 m. ha would require at least 2.5 lac engineers based on a simple norm that one qualified engineer would be sufficient to cover a total net irrigated area of 100 ha, which includes all tasks related to planning, project execution, operation and management of the irrigation system, India would require a total of at least 2.5 lac irrigation engineers. In addition, if we want to manage millions of ha of watersheds, which become the catchment of river basins, additional qualified engineers in the field of soil and water engineering would be required.

Let us assume that a total watershed area of 5,000 ha (50 sq. km or 10 average micro watersheds) would require one soil & water engineer for tasks related to watershed planning, execution of watershed treatment activities, and supervision of maintenance of watershed structures. Let us also assume that nearly one third of the geographical area of India form good, well-defined upper catchment watersheds of major river basins (20 of them), which require treatment for erosion prevention, soil moisture conservation and runoff regulation. This means, we would require at least 22,000 soil & water engineers. Hence, annually, India would require 3.92 lac engineers, who can be trained to perform water management related functions. This means, India would require on an average, 325 civil engineers for a population of one million people. What is probably available from the market annually is just 1/20th of this requirement.

Further, one should believe that the technical manpower in public sector agencies in India's water sector currently falls far short of this requirement. One could also inf · that this staff deficit would continue for many years to come. The following arguments support this. *First*: the public sector in India employed only 75,921 engineers (including 33,331 diploma engineers) in 2002 (based on responses from 73.1 per cent of the public sector Indian establishments, Government of India, n.d.). *Second*: the number of employees retiring every year from government departments is nearly 20 per cent of the total number of employees. The public sector agencies advertised for a total of only 17,507 vacancies for engineers (including 4663 diploma engineers) in 2005 (Government of India, 2008). If we make the optimistic assumption that the number of new recruits is equal to the total number of employees retiring annually, the total strength of civil engineers employed in public sector would be in the range of 85 to 100,000.

6. Training in Water Sector

There are many training institutions catering to the needs of the country's water agencies such as National Water Academy (NWA), National Ground Water Training and Research Institute (NGWTRI), state water resources (irrigation) department, water supply department, ground water planning & evaluation agencies, and water and land management institutions. But these institutions were equipped to deal with the issue concerning development of water resources. For instance, groundwater prospecting, geo-hydrological surveys, drilling technologies, and water level and quality monitoring are some of the areas in which the state groundwater departments undertake training. Hence, they have largely a technical orientation. The challenge is to prepare these institutions in handling some of the emerging themes in the sector, such as water resources management, water allocation and water demand management, which have strong ecological, economic and social focus.

For instance, because of resource and staff constraints, the Central Ground Water Board (CGWB) monitors very few wells periodically across the country, and the Central Pollution Control Board maintains very few stations for water quality monitoring. This severely limits their ability to put together timely management responses. But proper engagement of civil society groups in resource monitoring can help increase the density of observation stations for water levels and water quality, in a cost-effective manner. With the vital database on water resource availability and water quality accessible to the local community, the concerned actors (like the municipality or an industrial unit) would become more accountable to them, thereby directly impacting on water governance. But this would require many soft skills in managing people.

That the world of professional water resource planners, decision makers and managers is no longer the same as that in the past has been noted by many scholars. As Priscoli and Wolf (2009) reiterate in their work on *Managing and Transforming Water Conflicts*: "Today, especially in the context of new demands for integrated water resources management (IWRM), the water planners and managers have to work in teams involving multiple disciplines, rather than just engineering and associated technical fields." Hence, revamping these institutions, with multi-disciplinary focus, to meet the future challenges is a critical issue. Though this has started happening in limited cases, they are rather exceptions than the rule.

Building skills for managing water resources is not limited to building the human resource capabilities of the line agencies alone. It is also essential for the primary users of the resource such as farmers, urban water users and rural drinking water users. This is crucial for capacity building in the water sector.

Capacity building of primary stakeholders can be achieved through training. But the issue is one of creating adequate number of institutions which are capable of handling this unique task. There is not much clarity on the nature of institutions which can handle these tasks. Whether civil society institutions can handle these tasks, if equipped with adequate resources and skills, needs to be reviewed. Further shortage of essential field equipment for monitoring/extension activities along with lack of funds at the operational level put constraints on carrying out essential capacity building interventions.

That said, the types of skills that the primary water users require for managing their affairs are drastically different from those required by official agencies. For instance, the agency concerned with institutional financing for micro irrigation (MI) systems needs to know where MI systems produce the intended benefits; and what is the system design that will make MI more effective (refer Kumar, 2016). Whereas the farmers who want to use the system need to know what type of system (whether a drip system or a micro sprinkler or an overhead sprinkler) is most suitable for his crops. Similarly, the agency managing groundwater needs to know the ways to estimate the sustainable levels of extraction for the aquifers. But the farmers would be interested in knowing the depth to which the well should be drilled to get good yields and good quality water. Hence, the contents of the training will have to be different for different stakeholders, and even across areas.

In sum, the strategies for human resource capacities needs to be tailor-made so as to suite respective stakeholders possessing different degrees of knowledge, skills, responsibilities and needs. But there is a major concern on the limited number of skilled professionals and technicians to train, educate, and transfer knowledge and experience to different stakeholders.

As a national- and local-level capacity building effort, there is need to develop policy dialogues with all stakeholders in water resources and water services, especially local communities, consumers, public and organizations that relates to water but are outside the water sector proper, decision makers and politicians. These efforts shall be able to increase their awareness and knowledge about their prospective role in water management issues and policy, especially where these affect their future (Alaerts *et al.*, 1999). But, for effective capacity building and awareness creation among stakeholders, information exchange, communication and data-sharing are prerequisites.

The social, cultural, technical, economic and natural environment of the water sector is in constant flux (Wihuri *et al.*, 2003). It must also be recognized that each country and region has its specific characteristics and requirements with respect to its water resources situation and its institutional framework. Therefore, operational strategies for water sector capacity building shall be long-term, with the main objectives of improving the quality of decision making, and sector efficiency in terms of managerial and operational performance in planning and implementation of water sector projects (Hamdy *et al.*, 1998). Thus, there is a need for careful planning, designing and implementation of capacity building activities in order to achieve substantial success in integrated water resources development and management.

7. Conclusions

With the passing of time and growing water scarcity, the priorities for the water agencies of the country have broadened from mere water development to encompass water resources allocation and management, whereas the challenge facing the primary stakeholders of water is to manage the demand for water without compromising on the social, economic and ecological benefits derived from its use. But the water agencies have not kept pace with the changing needs and priorities of the sector. On the contrary, the approach of agencies concerned is becoming largely construction-centric. The recent years have seen humungous investment in the water sector for rehabilitation of millions of existing tanks and ponds, and construction of small water harvesting systems under various government schemes. But there is no focus on the overall institutional capacity of the agencies for ensuring physical, economic and environmental sustainability of the hydrological systems and water supply systems.

The key to building institutional capacity is framing the right kind of water policies; crafting the right kind of rules and regulations, institutions and instruments; bringing about the needed organizational changes in the agencies concerned for water resources management and sustainable water allocation. The issues faced in this context are: a] building teams of professionals with multi-disciplinary skills, which can provide research and expert inputs for policy formulation, institutional building and design of economic instruments; b] mobilizing resources and skills for creating new organizations including the development of local institutions, and restructuring some of the existing ones; and c] raising the overall strength of technical staff in various departments engaged in water resources development, management and water related services. Finally, availability of sufficient number of professional agencies which can design and implement capacity building programmes for various stakeholders is a critical issue.

The focus of the state and central governments should be on building world-class human resource base with trainers, researchers and water management professionals with multi-disciplinary skills, engineers and technicians to face the future water challenges related to water resources management and water allocation. These challenges lie in framing sound policies and building institutional capacities.

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Without natural resources life itself is impossible. From birth to death, natural resources, transformed for human use, feed, clothe, shelter, and transport us. Upon them we depend for every material necessity, comfort, convenience, and protection in our lives. Without abundant resources prosperity is out of reach.

–Gifford Pinchot

The Resource Management in Chennai Heavy Engineering Cluster

E. BHASKARAN

Micro and Small Manufacturing Enterprises in Chennai who are manufacturing Heavy Engineering Components are dependent on common infrastructure resource, technology resource, procurement resource, production resource and marketing resource by adopting Cluster Development Approach. They formed the Chennai Heavy Engineering Cluster (CHEC) to make use of common resources through interrelationships, for cost minimization and profit maximization. The objective is to study on the Resource Management of CHEC and to find Difference in Differences (DID) on the control variable, and experimental variables on productivity after Government of India and Tamil Nadu Policy interventions on CHEC. Physical Performance is an increasing trend for a number of units for employment and machinery, and also for financial performance like Turnover as per increasing CAGR. To conclude, as per DID the control group (who have not undergone Cluster Development Approach) and Treatment Group (who have undergone Cluster Development Approach) have much Difference in Differences on employment, machinery, turnover and export, and there is an increase in productivity due to adoption of Cluster Development Approach by the experimental group by managing common resources available in the Cluster. The interrelationships / cluster approach made Chennai Heavy Engineering Enterprises and cluster members make use of resources like infrastructure, procurement, technology, production and marketing successfully.

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1. Introduction

Clusters can be defined as sectoral and geographical concentration of enterprises, in particular Small and Medium Enterprises (SME), faced with common opportunities and threats which can: Give rise to external economies (e.g. specialized suppliers of raw materials, components and machinery; sector specific skills etc.); Favor the emergence of specialized technical, administrative and financial services; Create a conducive ground for the development of inter-firm cooperation and specialization as well as of cooperation among public and private local institutions to promote local production, innovation and collective learning. Small and medium-sized enterprises (SMEs) are the most important source of employment generation in any country. [1]

The Ministry of Micro, Small and Medium Enterprises (MSME), Government of India (GoI) has adopted the Cluster Development approach as a key strategy for enhancing the productivity and competitiveness as well as capacity building of Micro and Small Enterprises (MSEs) and their collectives in the country. [2]

The establishment of Ashok Leyland in the late 50's and TVS group of companies in the early 60's then, Ford, Hyundai, Hindustan Motors, Royal Enfield, Tafe, TVSetc leads to development of Tier II, Tier III and Tier IV suppliers to Tier I / OEMs in Chennai. [3]

2. Technical Survey

Around 250 micro units and SPV members in the SIDCO Thirumullaivoyal Women Industrial Park, get benefitted by the establishment of the Heavy Machinery and Fabrication CFC. More than 36 employees are employed in this CFC. During the peak business, as of November to January, the turnover is from Rs.10 to Rs.15 lakhs per month, and huge business orders are expected in future.

The management of the CFC is so excellent and a handon training is offered for the new comers. SPV member of M/s. Lakshmi Industries says although he is without any machinery of his own and he is making a very good life with the help of the CFC. He is happy with the fair-minded treatment. He executes his order on time to the customers with the help of CFC Machinery.

Another Non-Member of M/s. Krishna Industries says that his total gain in 2019 was at an average of Rs. 5 lakhs, but after the establishment of the CFC he gains a minimum of Rs 11 lakh per month. He is very comfortable in executing his work orders on time because CFC established in SIDCO Thirumullivoyal Women's Industrial Park.

The CFC has increased the competency of the Heavy Machinery and Fabrication in the area by narrowing down the critical technological gap and satisfies the needs of valued customers from anywhere. It has provided value addition in SIDCO Industrial Area.

Many studies have been made to identify performance for Clusters under Cluster Development Approach like Match, Printing, Auto components, Leather, Plastic, Hosiery, Textile, Lorry Body Building, Pharmaceutical, Ceramic, Wet Grinder, Jewellery and Rice Mill [3]. Tamil Nadu is first to implement 24 clusters in India which includes Chennai Heavy Engineering Cluster [4]. A cluster is identified by two constituents – the product and the place, and is generally localized. [5] However the Resource Management in Industrial Clusters is not studied yet and this leads to study on Resource Management in Chennai Heavy Engineering Cluster.

3. Objectives of the Study

The objectives are :

1. To Study the physical and financial performance of CHEC before and after CDA.
2. To study the compound annual growth rate, descriptive analysis, correlation analysis, regression analysis and trend analysis of CHEC before and after CDA.
3. To study the difference in difference on the control variable and experimental variables after government intervention of CHEC.
4. To study the resource management of manufactures through value chain analysis.
5. To map the heavy engineering cluster model based on resources available.

4. Methodology

The methodology adopted is the collection of primary data from 59 Micro and Small Manufacturing Enterprises in CHEC of Tamil Nadu, South India before (2018–19) Cluster Development Approach (CDA_B) and after (2019–20) Cluster Development Approach (CDA_A). Secondary data is collected from Ministry of Micro, Small and Medium Enterprises (MSMEs), Government of India, and MSMEs, Government of Tamil Nadu, Department of Industries and Commerce, Government of Tamil Nadu (DIC), and Tamil Nadu Small Industries Development Corporation Limited (TANSIDCO) [1] to [14].

The data were analysed with descriptive analysis, correlation analysis, regression analysis, trend analysis, compound annual growth rate (CAGR), and analysis of variance (ANOVA) by taking the number of Units [U], employment in numbers [E], plant and machinery [P], year/time [Y] as independent variables and turnover [T] in crores and export in crores [E_2] as dependent variables. The difference in difference is also studied for control variable and experimental variables.

5. Technical Analysis

5.1 Physical Performance

The physical performance of plastic cluster is shown in Figures 1, 2, and 3.

Physical performance, as shown in Figures 1, 2, and 3, is an increasing trend for number of units with CAGR of 3.41, employment with CAGR of 2.78 and plant and machinery with CAGR of 27.39.

5.2 Financial Performance

The financial performance of plastic cluster is shown in Figure 4.

Financial performance as shown in 4 is an increasing trend for turnover with CAGR of 50.00. Based on the above data, it is found that the CFC resources are used and managed by Heavy Engineering Cluster members effectively.

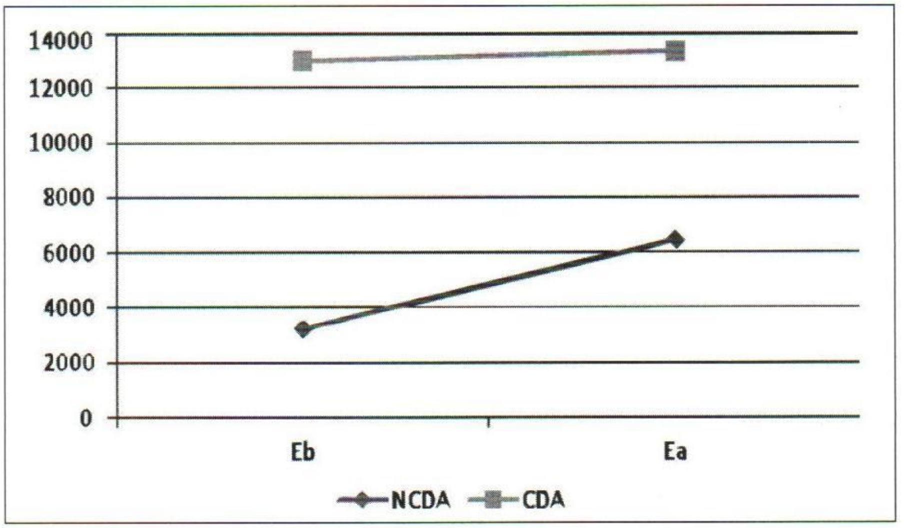


Figure 1: Employment

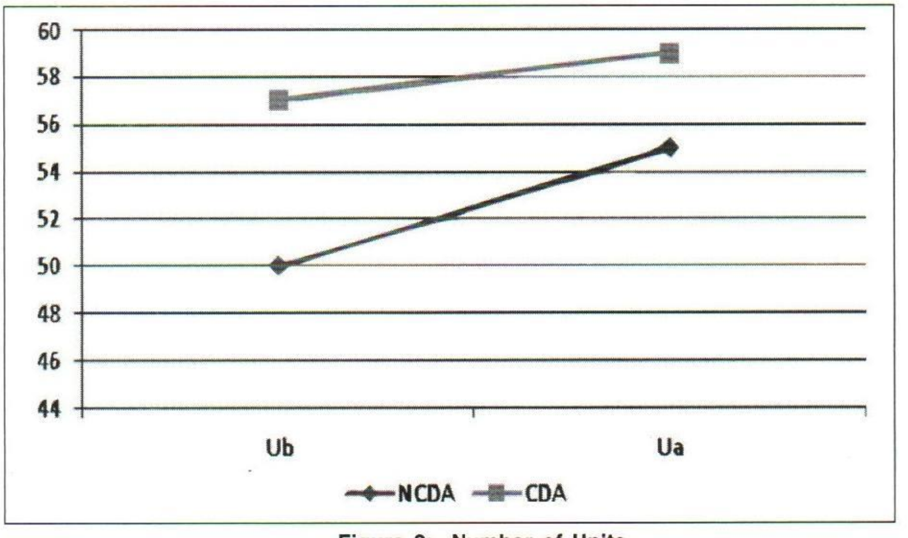


Figure 2: Number of Units

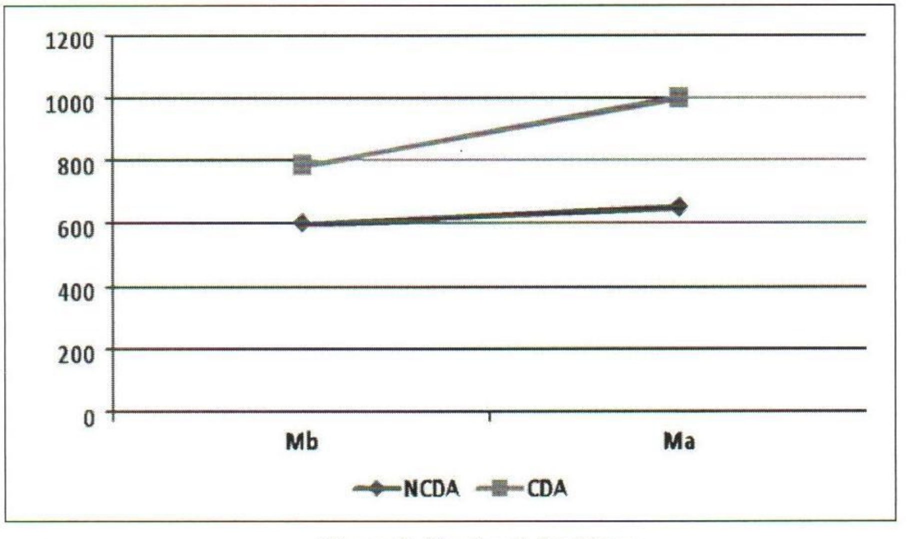


Figure 3: Plant and Machinery

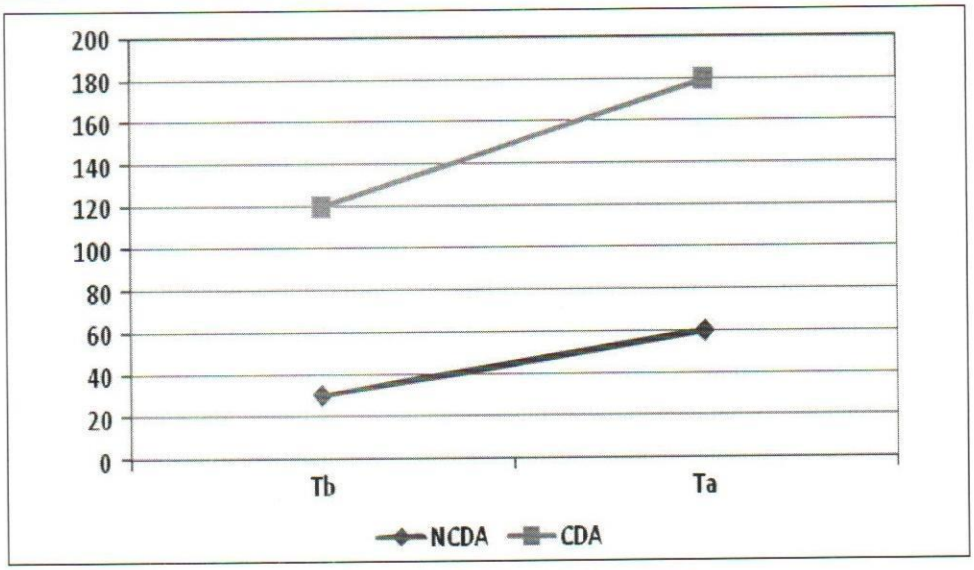
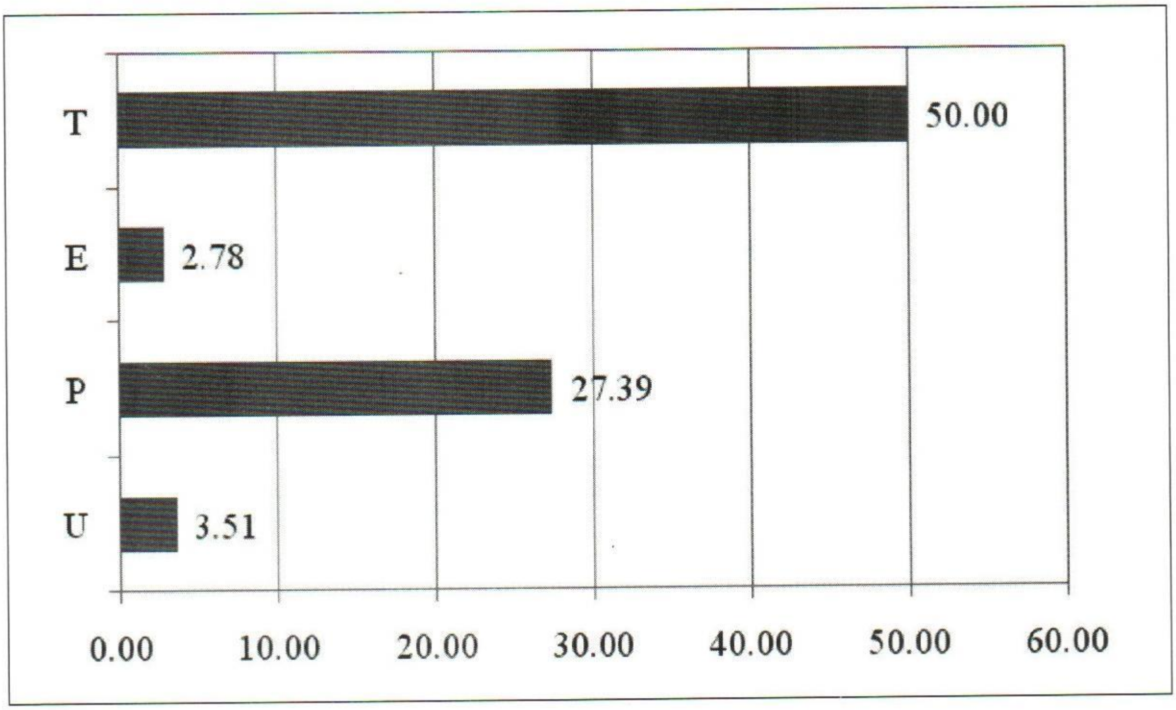


Figure 4: Financial Performance

5.3 Compound Annual Growth Rate (CAGR)

The Compound Annual Growth Rate (CAGR) is given in Figure 5.

As per Figure 5, there is an increase in CAGR of the number of units to 3.51 per cent, of employment to 2.78 per cent, and of plant and machinery to 27.39 per cent after CDA.



Source: HEC and computed data

Figure 5: Compound Annual Growth Rate (CAGR)

In general, the CAGR increases for both dependent variables like turnover and also for independent variables like number of units, employment and plant and machinery after CDA.

There is an annual average increase in dependent variables like turnover and also there is an annual average increase in independent variables like units, employment and plant and machinery after CDA.

5.4 Descriptive Analysis

The Descriptive Analysis is given in Table 1.

The mean value of units, employment, plant and machinery and turnover indicate that there is growth in all variables after CDA.

TABLE 1: Statistics

	Ub	Ua	Mb	Ma	Eb	Ea	Tb	Ta
Mean	53	59	692.5	825	8100	9900	75	120
Standard Error	2.5	1	92.5	175	4860	3420	45	60
Median	52.5	58	692.5	825	8100	9900	75	120
Standard Deviation	3.54	1.41	130.81	247.49	6873.08	4836.61	63.64	84.85
Sample Variance	12.5	2	17112.5	61250	47239200	23392800	4050	7200
Range	5	2	185	350	9720	6840	90	120
Minimum	50	57	600	650	3240	6480	30	60
Maximum	55	59	785	1000	12960	13320	120	180
Sum	105	116	1385	1650	16200	19800	150	240
Count	2	2	2	2	2	2	2	2
Confidence Level (95.0%)	31.76	12.70	1175.32	2223.58	61752.15	43455.22	571.78	762.37

Source: Computed Data.

5.5 Correlation Analysis

The correlation analysis is given in Table 2.

As per Table 2, there exists a significant positive relationship between number of units, and employment, production, and turnover after CDA. Higher number of units is associated with higher employment or human resource. Higher Machinery is associated with higher turnover due to efficient use of CFC resources. Higher Machinery is associated with Turnover due to high use of machinery resources. Higher turnover should be associated with higher export in future.

TABLE 2: Correlations

	Ub	Mb	Eb	Tb		Ua	Ma	Ea	Ta
Ub	1				Ua	1			
Mb	0.49	1			Ma	0.61	1		
Eb	0.54	0.998	1		Ea	0.05	0.82	1	
Tb	0.54	0.998	1	1	Ta	0.50	0.99	0.89	1

Source: Computed data

Higher dependent variables like turnover are associated with higher independent variables like units, employment, and machinery after CDA.

5.6 Regression Analysis

The Regression Analysis is given in Table 3.

TABLE 3: Regression Equations

Sl. No.	Regression Equations	R^2	p value	Result
1	T = -2040 + 0.17 E	$R^2 = 1$	p = 0.05	Significant
2	T = -236.47 + 0.42 M	$R^2 = 0.78$	p = 0.30	Not Significant
3	T = -2475 + 45 U	$R^2 = 0.75$	p = 0.33	Not Significant

Source: Computed data.

Regression equation 1, in Table 3 reveals that employment significantly predicts turnover, regression equation 2, reveals that machinery significantly predicts turnover and, regression equation 3 that the number of units significantly predicts turnover.

Higher dependent variables like turnover and exports significantly predict independent variables like units, employment, and production after CDA.

5.7 Trend Analysis

The Trend Analysis is given in Table 4.

As per trend equation 1 in Table 4, an annual average increase in the number of units is 57. As per trend equation 2 in Table 4, an annual average increase in employment is 360, where the human resource management improved. As per trend equation 3 in Table 4, an annual average increase in machinery is Rs. 112.5. As per trend equation 4 in Table 4, an annual average increase in turnover is 60.

There is an annual average increase in dependent variables like turnover, while there is also an annual average increase in independent variables like units, employment and machinery after CDA. It proves that entrepreneurs have made use of resources available in CFC.

TABLE 4: Trend Equations

Sl. No	Trend Equations	R^2	p Value	Result
1	U = 57.33 + T	$R^2 = 0.75$	p = 0.33	Non-Significant
2	E = 12600+360 T	$R^2 = 1$	p = 0.01	Significant
3	M = 740.83 + 112.5 T	$R^2 = 0.78$	p = 0.308	Not Significant
4	To = 60 + 60 T	$R^2 = 1$	p = 0.05	Significant

Source: Computed data.

5.8 Analysis Of Variance (One Way Anova)

The one-way ANOVA is given in Table 5.

Null Hypothesis 1: There is no significant difference in number of units before and after CDA.

Alternate Hypothesis 1: There is significant difference in number of units before and after CDA.

As per Table 5, $p > 0.05$, F < F critical, hence null hypothesis is accepted and alternate hypothesis is rejected i.e., there is no significant difference in number of units before and after CDA. However, as per Table 1, M (Mean) value on $CDA_A > CDA_B$ where there is significant increase in number of units after CDA.

Null Hypothesis 2: There is no significant difference in employment on before and after CDA.

Alternate Hypothesis 2: There is significant difference in employment on before and after CDA.

As per Table 5, $p > 0.05$, F < F Critical, hence null hypothesis is accepted and alternate hypothesis is rejected i.e., there is no significant difference in employment on before and after CDA. However, as per Table 1, M (Mean) value on $CDA_A > CDA_B$ where there is significant increase in employment after CDA.

Null Hypothesis 3: There is no significant difference in machinery on before and after CDA.

Alternate Hypothesis 3: There is significant difference in machinery on before and after CDA.

As per Table 6, $p > 0.05$, F < F Critical, hence null hypothesis is accepted and alternate hypothesis is

TABLE 5: ANOVA

		SS	df	MS	F	P-value	F crit
U	Between Groups	30.25	1	30.25	4.17	0.18	18.51
	Within Groups	14.5	2	7.25			
	Total	44.75	3				
E	Between Groups	3240000	1	3240000	0.09	0.79	18.51
	Within Groups	70632000	2	35316000			
	Total	73872000	3				
M	Between Groups	17556.25	1	17556.25	0.45	0.57	18.51
	Within Groups	78362.5	2	39181.25			
	Total	95918.75	3				
T	Between Groups	2025	1	2025	0.36	0.61	18.51
	Within Groups	11250	2	5625			
	Total	13275	3				

Source: Computed Data.

rejected i.e., there is no significant difference in machinery on before and after CDA. However, as per Table 5, M (Mean) value on $CDA_A > CDA_B$ where there is significant increase in machinery after CDA.

TABLE 6: Paired Samples Test

	Ua	Ub	Ma	Mb	Ea	Eb	Ta	Tb
Mean	58	52.5	825	692.5	9900	8100	120	75
Variance	2	12.5	61250	17112.5	23392800	47239200	7200	4050
Observations	2	2	2	2	2	2	2	2
Pearson Correlation	1		1		1		1	
Hypothesized Mean Difference	0		0		0		0	
Df	1		1		1		1	
t Stat	3.67		1.61		1.25		3	
P (T<=t) one-tail	0.08		0.18		0.21		0.10	
t Critical one-tail	6.31		6.31		6.31		6.31	
P (T<=t) two-tail	0.17		0.35		0.43		0.20	
t Critical two-tail	12.71		12.71		12.71		12.71	

Source: Computed Data.

Null Hypothesis 4: There is no significant difference in turnover on before and after CDA.

Alternate Hypothesis 4: There is significant difference in turnover on before and after CDA.

As per Table 6, p >0.05, F< F Critical, hence null hypothesis is accepted and alternate hypothesis is rejected i.e., there is no significant difference in turnover on before and after CDA. However, as per Table 5, M (Mean) value on $CDA_A > CDA_B$ where there is significant increase in production after CDA.

Paired Sample T-Test

The Paired Sample T-Test is given in Table 6.

As per Table 6, there is increase in number of units, employment, machinery, and turnover. The cluster and its members have used the human resource and machinery resource, and increased their turnover over the years due to CDA.

Difference in Differences (DID)

The Government of India and the Government of Tamil Nadu's policies on CDA are important for MSMEs. A test was conducted between control group (who have not undergone CDA) and treatment group (undergone CDA). The Treatment T for time t for employment, production, turnover and export formed is given in equation 1, 2, 3 and 4.

1. $U = 50 + 7\,T + 5\,t - 3\,DID$ .... [1]

   DID = -3, where the number of units is not significant in this cluster and needs improvement. More members should join to improve cluster.

2. $E = 6480 + 570\,T + 2000\,t + 4270\,DID$........... [2]

   DID = 4270, where the human resource is significant in this cluster.

3. $M = 600 + 185\,T + 50\,t + 165\,DID$............ [3]

   DID = 165, where the machinery resource is significant in this cluster.

4. $T = 30 + 90\,T + 30\,t + 30\,DID$............ [4]

   DID = 30, where the turnover is significant in this cluster.

5.9. Value Chain Analysis

The value-chain concept has been used to distinguish between cooperative strategies according to the type of resources pooled by the partners. This study is based on the value chain concept and integrated approach developed by the researcher on cluster development as shown in Table 7.

It has been discussed that cluster approach is a major motivating factor and enterprises are keen to accept the challenge to maximize their profits. Majority of enterprises are moderately satisfied with the infrastructure interrelationships, technology interrelationships, procurement interrelationships, production interrelationships and marketing interrelationships after the CDA, and made use of the resources available in the cluster.

5.10. Chennai Engineering Cluster Model

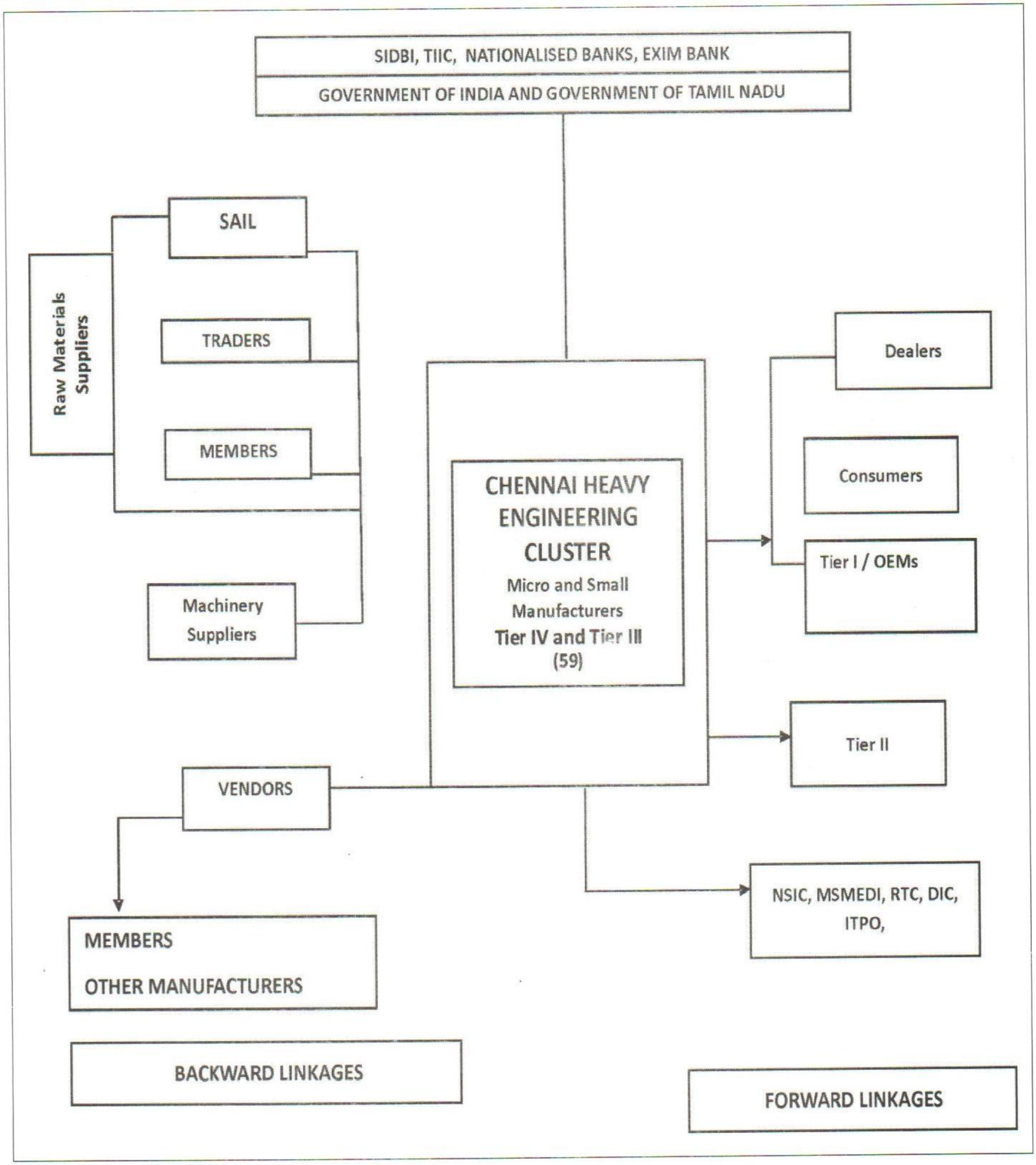
The CHEC model, as shown in Figure 6, indicates the cluster level linkages of all actors namely, TIIC-Tamil Nadu Industrial Investment Corporation, SIDBI-Small Industries Development Bank of India, EXIM Bank-Export Import Bank, SIDCO-Small Industries Development Corporation, SAGOSERVE, TANSTIA-Tamil Nadu Small and Tiny Industries Association, NSIC-National Small Industries Corporation, MSMEDI-Micro, Small and Medium Enterprises Development Institute, RTC-Regional Testing Centre, DIC-District Industries Centre, ITPO-Industrial Trade Promotion Organization, all were involved effectively in the formation and the supporting activities of CHEC.

From the outcome of the present study, it is obvious that CHEC has significant interrelationships among the enterprises. The location of the clusters play a crucial role in the integrated study. Constant involvement of industrial units in the cluster will improve their performance. The costs of the industrial units have considerably reduced due to the intervention, and the profits increased sizeably. The policy planners can identify the parameters of industrial growth in different locations of the region using CDA. The outcome of CDA will attract the financial investors to concentrate more on specified industrial centres for investment. This will improve the economic status of the region, thus rendering overall development. The CHEC model indicates the cluster level linkages of all actors involved effectively in the formation and the supporting activities of CHEC. The interrelationships made cluster members make use of resources like infrastructure, procurement, technology, production and marketing. The financial resources used by cluster and MSE are shown in Figure 7.

Table 7: Value Chain Analysis for CHEC

<table>
<tr><td rowspan="4">SUPPORT ACTIVITIES</td><td>Infrastructure</td><td colspan="5">With Government of Tamil Nadu through TANSIDCO and Government of India assistance created CFC. Facilities at CFC are warehouse, laboratory etc.</td><td rowspan="2">Infrastructure interrelationships</td><td rowspan="7">PROFIT</td></tr>
<tr><td>Human Resource Management</td><td colspan="5">Cluster based human resource strategy is also implemented where the recruitment, retention, replacement, internal career development and skill development training of individual firms is taken care. The training centre has laboratories and skill development centres to train and impart technical skills to employees.</td></tr>
<tr><td>Technology Development</td><td colspan="5">Technology awareness / training programmes and technology transfer schemes, including joint ventures and quality upgradation are conducted, and thereby, technology interrelationships have taken place. MSMEs have used the technology resources available in the cluster.</td><td>Technology interrelationships</td></tr>
<tr><td>Procurement</td><td colspan="5">The common raw material bank (consortia) created under Public Private Partnership (PPP) concept leads to best quality inputs with low input costs and Just in Time (JIT) model. The industrial estate has got a raw material depot, and going through them, the industries have got the raw materials like tapioca roots (Sago) in lesser cost (10% to 20%) compared to open market.</td><td>Procurement interrelationships</td></tr>
<tr><td rowspan="3"></td><td rowspan="2">Primary Activities</td><td colspan="3"></td><td colspan="2"></td><td rowspan="3"></td></tr>
<tr><td>Inbound Logistics</td><td>Operations</td><td>Outbound Logistics</td><td>Marketing/ Sales</td><td>Services</td></tr>
<tr><td></td><td colspan="3">Production Interrelationships Resource</td><td colspan="2">Marketing Interrelationships Resource</td></tr>
</table>

Source: Developed by Researcher



Source: Developed by Researcher

Figure 6: Chennai Heavy Engineering Cluster Model

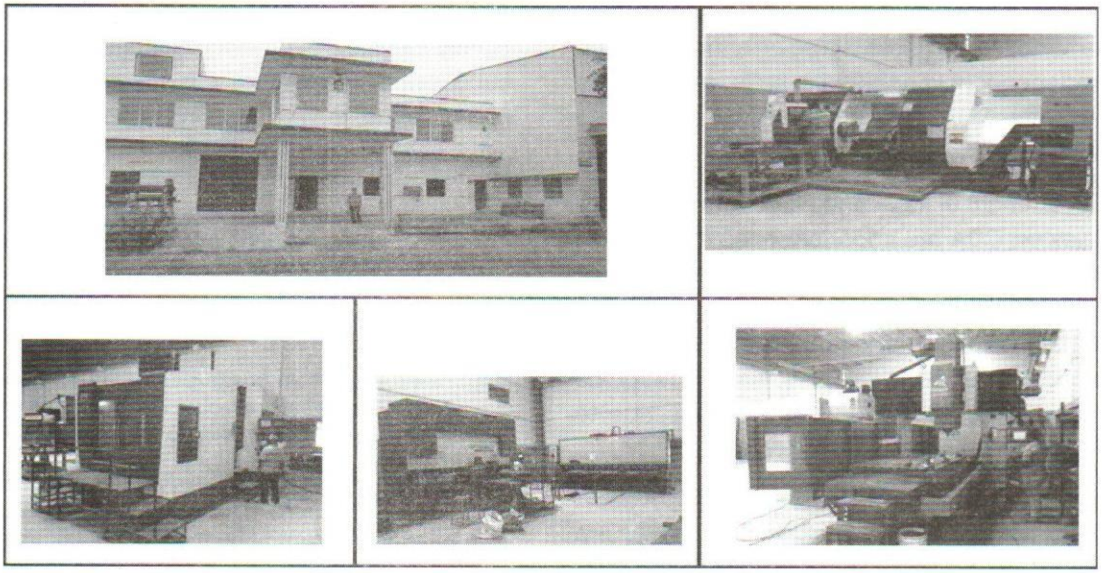


Figure 7: Common Facility Centre Resources Created at CHEC

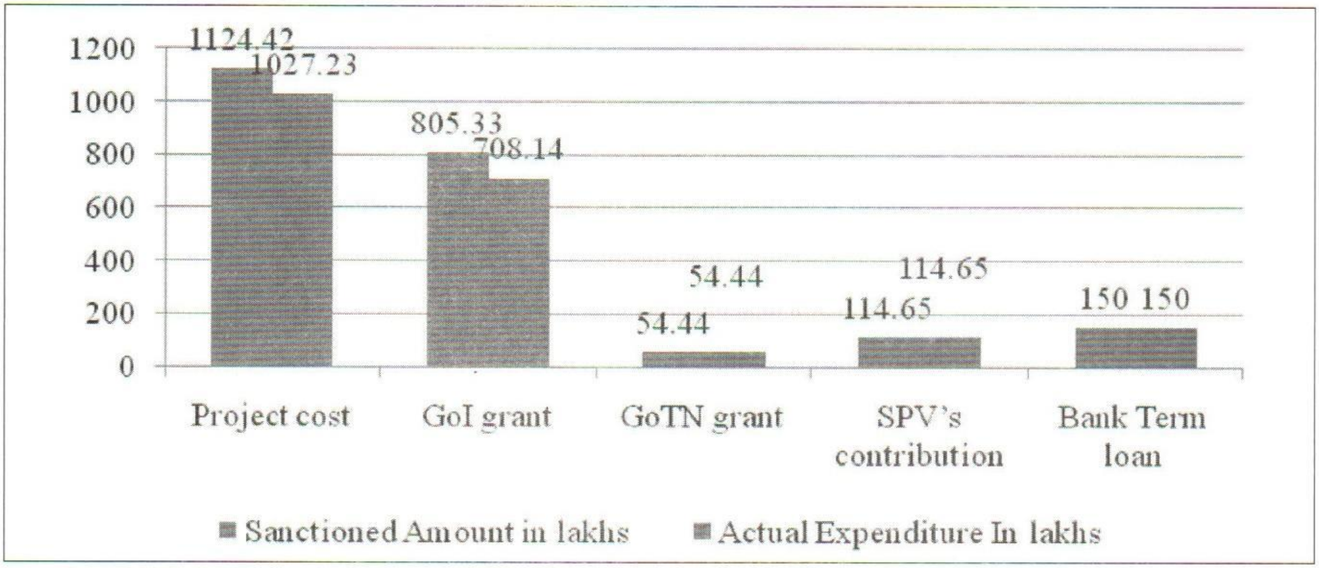


Figure 8: Financial Resources

6. Findings, Suggestions and Conclusion

A study was conducted on the resource management available in the cluster, and to find difference in differences on the control variable and experimental variables after government intervention. Physical performance is an increasing trend for number of units, employment and machinery, and also for financial performance like turnover, as per increasing CAGR. The mean value of units, employment, machinery and turnover indicates that there is growth in all variables after CDA. There exists a significant positive relationship between the number of units, and employment, machinery and turnover after CDA. Higher number of units are associated with higher employment. Higher production is associated with higher turnover. Higher machinery is associated with more production. Higher turnover is associated with higher export.

Higher dependent variables like turnover are associated with higher independent variables like units, employment, and machinery after CDA. Employment significantly predicts turnover. Production significantly predicts turnover and exports. Number of units significantly predicts turnover.

There is an annual average increase in dependent variables like turnover, and there is also an annual average increase in independent variables like units, employment and machinery after CDA. There is a significant difference in employment, machinery, and turnover after CDA.

The Government of India and Government of Tamil Nadu's policies on CDA are important ones for MSMEs. As per DID, the control group (who have not undergone CDA) and treatment group (who have undergone CDA) have much difference in differences on units, employment, machinery and turnover, and there is increase in resource utilisation. This leads to productivity increase due to adoption of CDA by the experimental group.

Cluster development is one of the excellent concepts for developing MSMEs. For this, GOI and GOTN are supporting where TANSIDCO is the implementing agency. All the departments in the State as well as the Centre are very co-operative for the implementation of the project. The interrelationships / cluster approach made Chennai Heavy Engineering Enterprises and cluster members to successfully make use of resources like infrastructure, procurement, technology, production and marketing.

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The basic economic resource - the means of production - is no longer capital, nor natural resources, nor labor.It is and will be knowledge.

– Peter Drucker

Biomedical Waste Resource Management: Opportunities and Challenges

RAVEESH AGARWAL AND ALOK GUPTA

Due to COVID-19, the generation of biomedical waste is increasing many times. Government has taken several initiatives for biomedical waste management. The objectives of this paper are to study the current practices related to biomedical waste management and to know about how we can convert waste to wealth by utilizing the resources. The data for this research paper is collected from secondary sources. It is found that we need more initiatives for biomedical waste management. This paper also highlights the challenges while offering some suggestions related to biomedical waste resource management.

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1. Introduction

We are aware that medical-related activities generate tonnes of waste every day and it is increasing day by day, especially in COVID-19 period. Although we used to give emphasis on "3 R Rules: Reduce, Reuse and Recycle with the objective of zero waste in landfill", it is very difficult to meet this objective. There are different methods and practices adopted by different countries to manage biomedical waste. One of the most popular methods is to collect waste from hospitals, nursing homes, medical laboratories, biomedical research facility centres and other healthcare institutions, and then move it to incineration plants for further processing. It involves serious risk of disease transmission among waste pickers, sanitary and waste workers, surrounding communities and other people involved in waste management directly or indirectly. It is subject to strict legislation to minimize the health risk for the society and environment.

2. Review of Literature

Priya *et al.,* (2018) observed that biomedical waste management (BMWM) should be a shared teamwork with committed government backing, and a strong legislature. It is our fundamental right to live in a clean and safe environment and the BMWM 2016 rules are an improvement over earlier rules in terms of improved segregation, transportation, and disposal methods, to decrease environmental pollution and ensure the safety of the staff, patients, and public. Acharya *et al.,* (2000) found that handling, segregation, mutilation, disinfection, storage, transportation and final disposal are important for biomedical waste management in any establishment. In their paper, U Jagadeesh Chandira Boss *et al.,* (2009) observed that there is a lack of segregation between infectious and noninfectious BMW as well as a failure to implement the prescribed rules for proper management of BMW; improper treatment and transportation and inadequate training of personnel, insufficient personal protective equipment, etc. Malini R Capoor *et al.,* (2017) reviewed the current perspectives on BMWM and rules, conventions and the treatment technologies used worldwide and it should ideally be the subject of a national strategy with dedicated infrastructure, cradle-to-grave legislation, competent regulatory authority and trained personnel to ensure the safety of the health-care workers, patients, public and environment. Md Sohrab Hossain *et al.,* (2011) observed that the adoption of SF-CO2 sterilization technology in management of clinical solid waste can reduce exposure to infectious waste, decrease labour, lower costs, and yield better compliance with regulation. Thus healthcare facilities can both save money and provide a safe environment for patients, healthcare staff and clinical staff.

Saurabh Gupta *et al.,* (2009) emphasized the need to create awareness among all stakeholders about the importance of biomedical waste management and related regulations, and should be supported through appropriate education, training, and the commitment of the healthcare staff and management and healthcare managers within an effective policy and legislative framework. In their study titled Health-care Waste Management in India, Patil and Shekdar (2001) pointed out that in many places, authorities are failing to install appropriate systems for a variety of reasons, such as non-availability of appropriate technologies, inadequate financial resources and absence of professional training on waste management. The authors further identified hazards associated with health-care waste management and shortcomings in the existing system and appraised the rules for management and handling of biomedical wastes, and suggested storage containers including colour-coding and treatment options. In their study, A Batters *et al.,* (1999) observed that in recent years, many poorer countries have chosen to use disposable, instead of sterilizable, syringes. Unfortunately, the infrastructure and management systems that are vital for disposables to be used safely do not exist. It is observed that most of the existing studies analyze biomedical waste management in relation to developed countries but there are less studies on how to convert waste to wealth business in relation to developed countries. Viewing this important research gap, the objectives of this research paper are developed.

3. Research Objectives and Methodology

The objectives of this paper are to study the current practices related to the various biomedical waste management and to know about how we can convert waste to wealth by utilizing the resources. This paper also highlights the challenges faced and offers some suggestions related to biomedical waste resource management. The data for this research paper is collected from secondary sources. It is carried out by reviewing the literature, published articles, journals, magazines, newspapers, books and other studies conducted by regulatory authorities, and other professional bodies available on the subject.

4. 5 W'S of Biomedical Waste

4.1 What is biomedical waste?

4.2 Where is biomedical waste generated?

4.3 Why do we require segregation, treatment and disposal of biomedical waste?

4.4 When should biomedical waste be segregated?

4.5 Who should segregate biomedical waste?

4.1 What is Biomedical Waste?

According to the U.S. Environmental Protection Agency, medical waste is a subset of wastes generated at health-care facilities, such as hospitals, physicians' offices, dental practices, blood banks, and veterinary hospitals/clinics, as well as medical research facilities and laboratories.[3] "Bio-medical waste" means any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps.[4] Biomedical waste or health-care waste includes all the waste generated by health-care establishments, research facilities and laboratories. In addition, it includes the waste originating from "minor" or "scattered" sources—such as that produced in the course of health-care undertaken in the home (dialysis, insulin injections, etc.).[5] Waste generated by health-care activities includes a broad range of materials, from used needles and syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices and radioactive materials.[6] According to the National Health-Care Waste Management Plan guidance manual by WHO[7], health-care waste are classified as depicted in figure 1.

HealthCare Waste

- **A: Non-risk HCW**
  - **A1:** Recyclable waste
  - **A2:** Biodegradable waste
  - **A3:** other non-risk waste
- **B: HCW requiring special attention**
  - **B1:** Human anatomical waste
  - **B2:** Sharps
  - **B3:** Pharmaceutical waste
    - **B31:** Non-hazardous Pharmaceutical waste
    - **B32:** Potentially hazardous Pharmaceutical waste
    - **B33:** Hazardous Pharmaceutical waste
  - **B4:** Cyto-toxic pharmaceutical waste
  - **B5:** Blood and body fluids
- **C: Infectious and highly infectious waste**
  - **C1:** Infectious waste
  - **C2:** Highly infectious waste
- **D: Other hazardous waste**
- **E: Radioactive waste**

Source: National Health-Care Waste Management Plan: Guidance Manual, WHO

Figure 1: Classification of Health-Care Waste

There are different types of biomedical waste as listed in Table 1.

Biomedical waste may contain the following items:

- Medicine wrapper, bottles
- Discarded and date-expired drugs, medicines, pills, cream
- Used gloves, caps, mask, shoe-cover, apron, linen gown face-shield, non-plastic or semi-plastic coverall
- Syringes, scalpels, needles, blades, razors , broken glass
- Urine bags
- Used blood bags
- Drain bags
- Diapers
- Items used at the time of surgery like cotton, syringe, injection, insulin, bandage, nappy
- Soaked tissue/cotton
- Body fluid

Table 1: Types of Biomedical Waste

Anatomical Waste	Identifiable body part, organs, pathological and biopsy specimens, human or animal tissue, blood bags and blood preserves, etc.
Chemical Waste	Includes solids, liquids or gases, made from harmful chemicals
Cytotoxic / Cytostatic Waste	Drugs/medicines in tablet, liquid, cream or aerosol form, contaminated by cytotoxic and cytostatic medicines
Domestic/General/ Municipal Waste	Generally non-hazardous waste, generated as a result of day-to-day activities
Genotoxic Waste	Hazardous waste/cytotoxic drugs, may have carcinogenic/mutagenic/ teratogenic properties
Hazardous Waste	Dangerous to environment and human health, generally non infectious
Infectious Waste	Cause infection and disease in humans or contaminated with blood and other bodily fluids
Offensive Waste	Non-infectious waste
Pathological Waste	Include everything from lab cultures and stocks
Pharmaceutical Waste	Expired, unused, contaminated damaged, discarded medicinal drugs/ medicines/cream
Radioactive Waste	Containing radioactive materials/ nuclear substance

Source: Compiled by authors based on different studies

- Plastic vials
- Bedding, towels and clothes of patients
- Discarded medical equipment
- Waste from autopsies
- Human-derived tissues, organs and body parts
- Surgical specimens
- Radioactive nuclear substance

4.2 Where is biomedical waste generated?

According to CPCB, biomedical waste is any waste generated during the diagnosis, treatment, immunization of human beings, human tissues, items contaminated with blood, body fluids like dressings, beddings, syringes or any other contaminated sharp objects.[8] It is generated by the following:[9]

- Hospitals
- Nursing Homes
- Clinics
- Dispensaries
- Veterinary Institutions
- Animal Houses
- Pathological Laboratories
- Blood Banks
- Ayush Hospitals
- Clinical Establishments
- Research or Educational Institutions
- Health Camps/Vaccination camps/Medical or Surgical Camps, Blood Donation Camps
- First aid rooms of Schools
- Forensic Laboratories and Research Labs

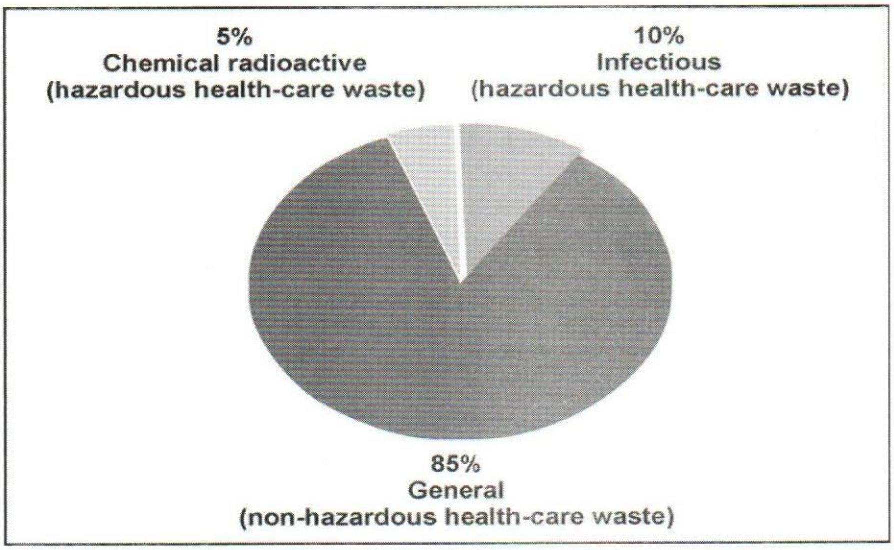
Biomedical waste may be generated due to the following activities:

- Research activities related to medical fields
- Drug administration
- Testing and production of biological
- In diagnosis, Sample Collection

- During treatment of patients, Surgical Procedure
- Immunization
- Clinical Trials

4.3 Why do we require segregation, treatment and disposal of biomedical waste?

Any waste may cause harm to the environment and public health if appropriate steps for segregation, treatment and disposal of waste are not taken. There must be proper segregation of all types of wastage at source. There is a strong need for segregation of different waste at household level and community level because biomedical waste can cause direct health hazards and adversely affect human health who get in touch with it due to risk of infection and other diseases. According to the World Health Organisation (WHO), nearly 85 per cent of all waste generated by hospitals is general, non-hazardous waste, as shown in figure 2. The remaining 15 per cent of waste is considered hazardous. It may contain infectious, chemical or radioactive materials.[10]



Source: Safe management of wastes from health-care activities: a summary

Figure 2: Waste Composition in Health-Care

4.4 When should biomedical waste be segregated?

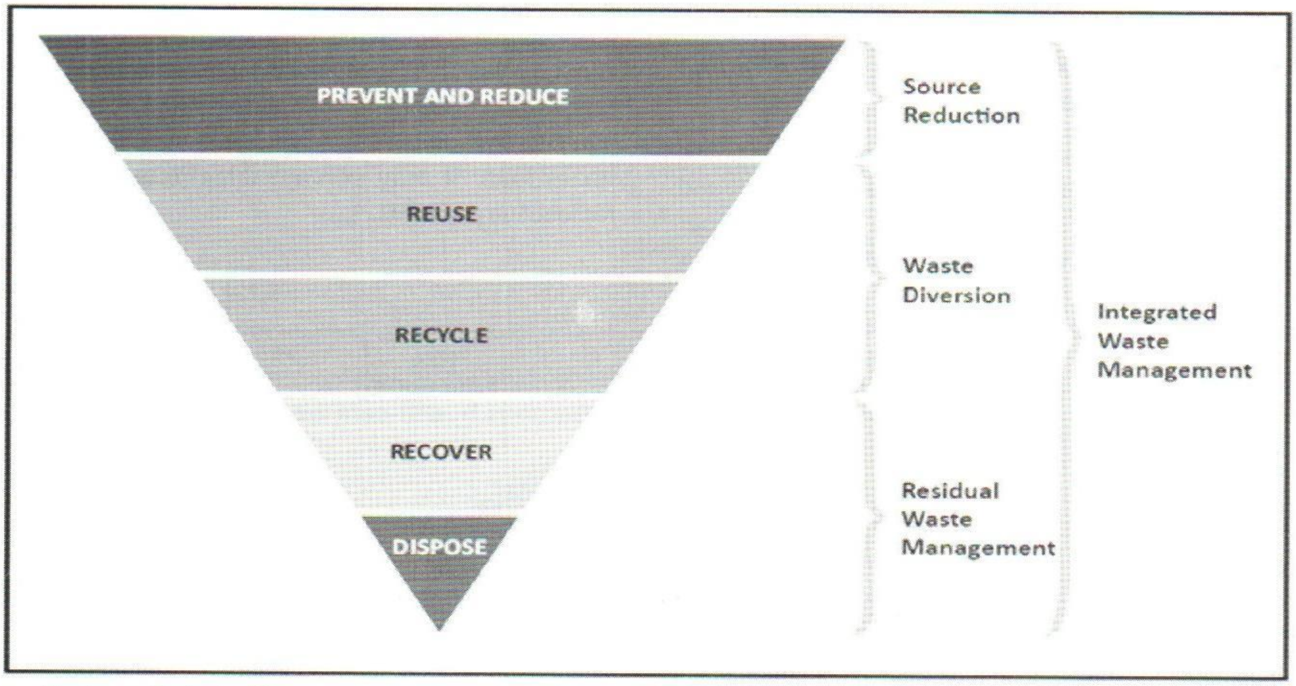
Biomedical waste should be segregated at the point of generation so that it should not be mixed with other waste. "Point of Generation" means the location where wastes initially generate, accumulate and is under the control of the operator of the waste-generating process.[11] If biomedical waste is mixed with other waste, it will be very difficult to segregate later on. It is necessary for reducing the risk of injury and infection to those persons who are engaged in waste management. It also plays an important role in reducing the volume of infectious waste.

4.5 Who should segregate biomedical waste?

Individuals or groups of people like doctors, nursing and paramedical staff, lab technicians, hospital maintenance personnel, ward boys, sanitary staff members related to health-care or any other person who is/are directly or indirectly involved in generating the waste should segregate it at source, into appropriate containers from other waste.

5. Waste Resource Management

Waste is a resource or a problem? It depends upon on how we manage waste. "Management" includes all steps required to ensure that bio-medical waste is managed in such a manner as to protect health and environment against any adverse effects due to handling of such waste.[12] Waste Resource Management is hierarchical processes related to the different stages after collection of the waste. Waste Hierarchy provides a framework for waste management options to set out the priority in order to make the correct choice about how to deal with waste.[13] It is based on the concept of "3Rs" (Reduce, Reuse and Recycle). Since the amount of waste is increasing day by day, there is an urgent need to focus on reduction, reuse and recycling of waste or any other methods by which we can obtain useful resources. Waste Hierarchy (Figure 3) shows a shift in how we view waste, how we manage it for protecting the environment, the health and the nation.[14]



Source: Northwest Territories Waste Resource Management Strategy and Implementation Plan (June 2019)

Figure 3: Waste Hierarchy

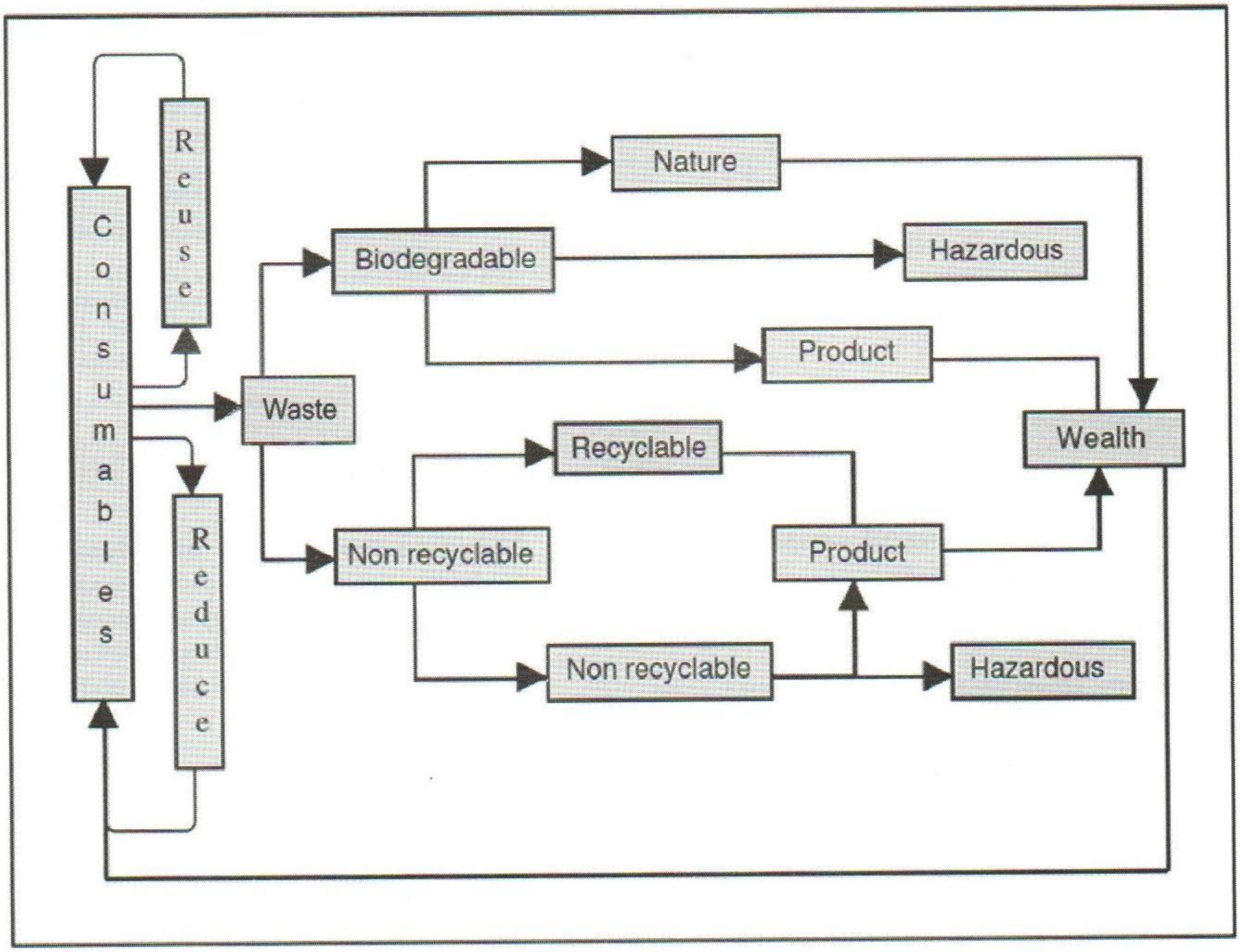
Waste is an important resource in its own way. We can treat it as a resource through extraction of material and energy from wastage. Waste can be converted into useful resources to achieve the goals of the 2030 Agenda for Sustainable Development. According to The United Nations Economic Commission for Europe (UNECE), about 3.6 million tonnes of municipal solid wastes are produced every day around the world, and if we could convert it all, it can produce energy equivalent to 3 million barrels of oil per day. It can produce 178 gigawatts of electricity.[15] Under thermal treatment, solid wastes can be converted into gasses through incineration where waste is used to burn at a high temperature which creates energy. Synthesised gas can be obtained through Pyrolysis, Hydrous Pyrolysis, Gasification, or Plasma Arc Gasification process which can be used to produce heat and electricity and solve the problem of energy crisis in India. Fossil fuels can be generated from waste through thermal decomposition processes. Solid waste can be converted into fuel briquettes. Rare-earth elements (REE) can be obtained from particular waste like phosphogypsum which contains radium. This radium can be processed and converted into useful medical products to treat cancer. The United Nations Framework Classification for Resources (UNFC) also provides guidelines to produce life-saving drugs and energy from waste mountains.[16]

Biomedical waste management is a crucial task. By proper management of resources, we can convert waste into useful materials and energy, and protect the environmental and public health. It will also lead to cleanliness and reduce the hazards and risk. Further, we can conserve the resources and move towards the sustainability of the ecosystem. There are basically five guiding principles which provide the basis of waste management effectively[17]. These principles are used in different countries while formulating their rules & regulations, policies and guidelines. These principles are as follows:

- Polluter pays Principle
- Precautionary Principle
- Duty of care Principle
- Proximity Principle
- Prior Informed Consent Principle

We can generate wealth through different processes[18] from waste as shown in Figure 4.

Effective segregation is the most important in biomedical waste management and it will be possible only when we focus on segregation of waste at source. In India, 530 metric tonnes of biomedical waste was treated and disposed per day in the year 2018.[19] It was estimated that the market value of biomedical waste was more than one billion rupees in 2018. It is also predicted that India will produce about 800 metric tonnes of biomedical waste per day by 2022.[20] As per study conducted by ASSOCHAM and Velocity, the current level of biomedical waste generation is 550.9 tonnes per day in 2020 and it will reach about 775.5 tonnes daily by 2022. It is expected to grow at a compounded annual growth rate (CAGR) of about 7 per cent.[21] According to the "Medical Waste Management Global Market Report 2020-30: COVID-19 Implications and Growth", the global medical waste management market is expected to grow from $13.5 billion in 2019 to 14.9 billion in 2020 at a CAGR of 10.6 per cent, mainly due to the COVID-19 outbreak and the measures to contain it. The un-estimated amount of biomedical waste being generated from COVID-treating hospitals, quarantine centres, healthcare facilities, and self/home-quarantine has triggered the need for medical waste management. The market is then expected to stabilize and reach $16.62 billion in 2023 at a CAGR of 3.8 per cent.[22] We can convert it into useful materials and energy, which can also help reduce carbon dioxide emissions into the environment. The raw material extracted from wastage during recycling and waste management process can be used to make a product again.



Source: Sub Theme-III, Waste to Wealth

Figure 4: Different Processes for Wealth Generation from Wastes

step	location	healthcare waste stream	key points
0		*waste minimization*	*purchasing policy; stock management; recycling of certain types of waste...*
1	in medical unit	**generation**	
2		**segregation at source**	*one of the most important steps to reduce risks and amount of hazardous waste*
3	in health facility	**collection + on-site transport**	*protective equipment; sealed containers; specific easy to wash trolleys*
4		**on-site storage**	*lockable easy to clean storage room; limited storage time of 24-48 hours*
5		**on-site treatment / disposal**	*adequate storage room; limited time of max 48 hours*
6	outside of health facility	**off-site transport**	*appropriate vehicle and consignement note; HCF is informed about final destination*
7		**off-site treatment / disposal**	*appropriate vehicle and consignement note to ensure...*

Source: Health-Care Waste Management Plan: Guidance Manual, WHO

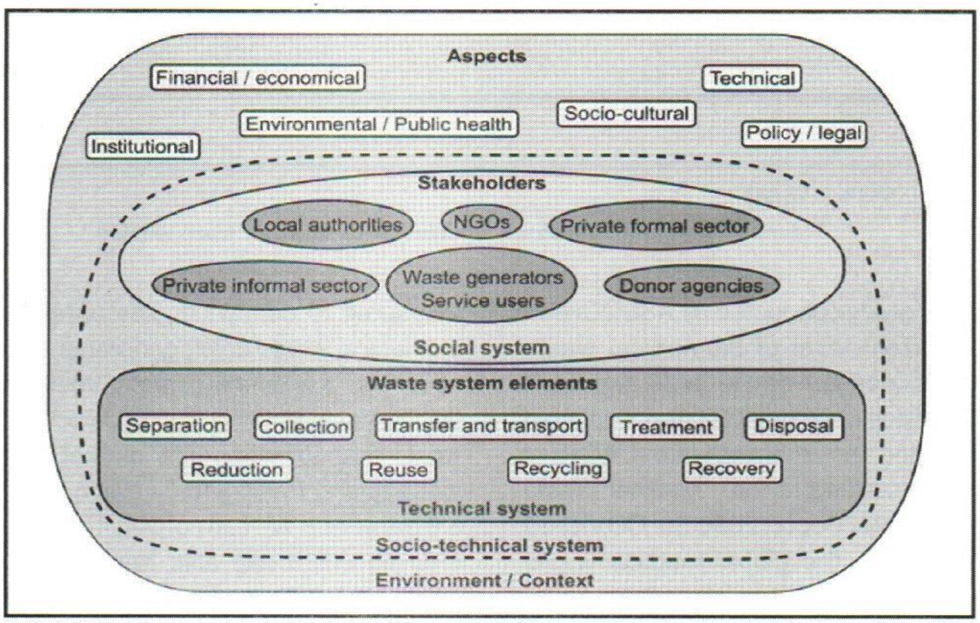
Figure 5: Common Steps related to Biomedical Waste Management

The common steps related to biomedical waste management are summarized in Figure 5.

6. Turning Waste to Resources: Efforts

We can divide the efforts into two groups related to turning the waste into resources.[23]

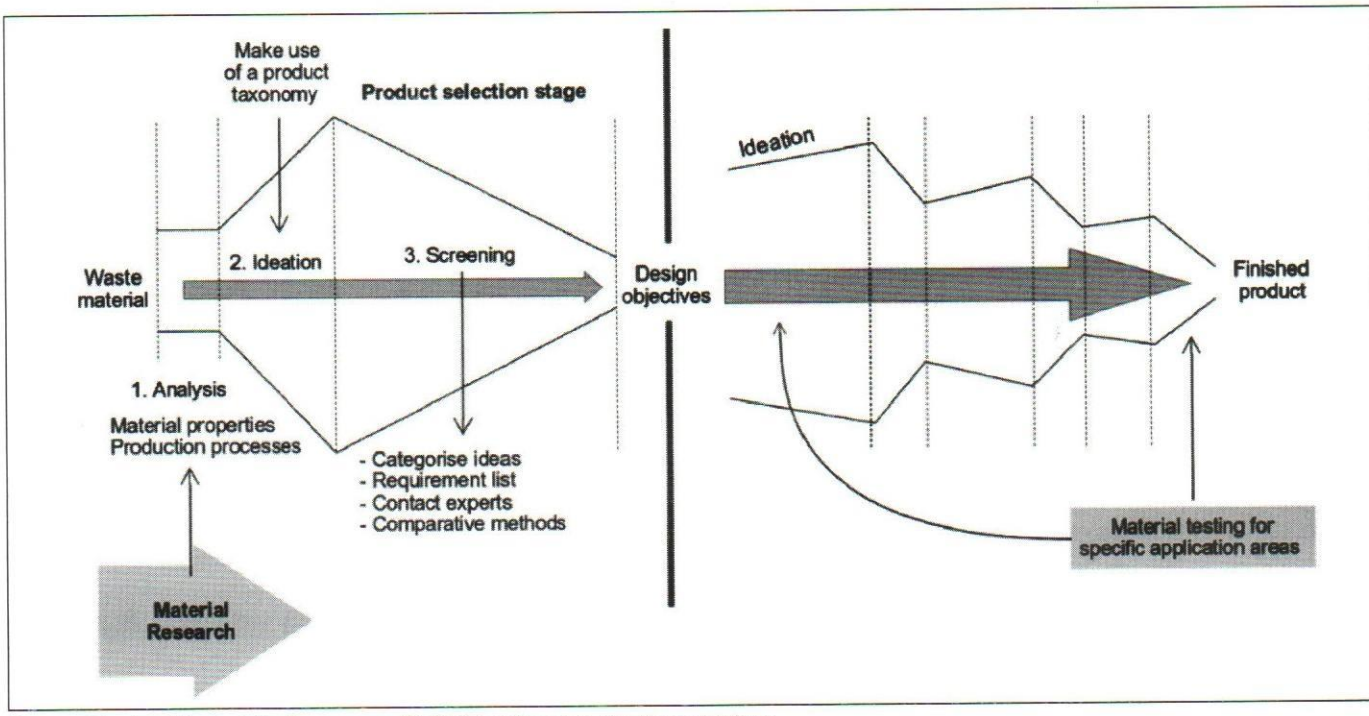
1. **Changing the mindset of industries and production system**: Manufacturers should make the products in a way so that they can retrieve the used products from the consumers and then reprocess it to make new products. It is based on the inverse logistics concept.



Source: Turning waste into resources: Rethinking the way we discard things

Figure 6: Integrated Sustainable Waste Management System

2. **Integrated Sustainable Waste Management:** It comprises of different dimensions like stakeholders, waste system elements and relevant aspects as mentioned in the ensuing figure.



Source: Turning Waste into Resources: Rethinking the way we discard things

Figure 7: The Process of Designing with Waste

The process of designing with waste was conducted by Department of Product and Production Development, Chalmers University of Technology, Sweden under waste to design project as shown in Figure 7.[24]

7. Rules & Guidelines for Handling, Treatment and Disposal of Biomedical Waste in India

There are proper guidelines available under Biomedical Waste Management Rules. These rules and guidelines are revised and updated time to time by the government. It is mandatory to follow the guidelines for management of biomedical waste by all stakeholders. In India, the Ministry of Environment, Forest and Climate Change (MoEF&CC), Central Pollution Control Board of India (CPCB), Ministry of Health & Family Welfare, Ministry of Jal Shakti, Ministry of Housing & Urban Affairs, Ministry of Defence, State Pollution Control Board, State Government Departments of Environment, Health and Urban Development, etc., directly or indirectly monitor and supervise the handling, treatment and scientific disposal of biomedical waste. They issue the necessary guidelines for handling, treatment and disposal of waste and amend it as per requirements to ensure protection of environment and public health. Under the Environment (Protection) Act, 1986, the Ministry of Environment & Forests (MoEF) notified Bio-medical Waste (Management & Handling) Rules, 1998. It classified the biomedical waste into ten categories. There were further amendments made and the Bio-medical Waste Management Rules, 2016 came into existence. Bio-medical Waste Management Rules, 2016 was also further amended. Following guidelines and rules are mentioned:

- BMWM rules 2016, amendments 2018, 2019
- CPCB guidelines for implementation 2018
- CPCB guidelines for COVID-19 waste, 2020

Central Pollution Control Board of India (CPCB) issued the special guidelines in relation to the novel Coronavirus disease (COVID-19) which provides detailed insight about safe disposal of waste in a scientific manner. The data related to biomedical waste is compiled and monitored through software application "COVID19BWM" at the time of generation, collection and disposal. It also tracks the vehicles and generates daily reports.

Biomedical waste management in a state is a complex task which involves the following stakeholders:[25]

- **State Level Bodies**
  - Advisory Committee
  - Pollution Control Board (PCB)
  - Directorate of Medical Health & Family Welfare
- **District Level Bodies**
  - District Monitoring Committee (DMC)
  - Municipal Bodies
  - Chief Medical Officer of the district
- **Facility Level Bodies**
  - Healthcare Facility (HCF) - Occupier
- **Common Biomedical Waste Treatment facilities (CBWTF)**
  (Collect, treat and dispose biomedical waste from healthcare facilities)

Generally Biomedical Waste Management Committee comprise SMO/CMO/Medical Superintendent, District Quality Consultant, District biomedical waste officer, Hospital Infection Control Officer, Nursing in-charge, Quality Manager, Medical Officer (Surgery, Emergency, Gynae & Obs), Microbiologist, Pathologist, Lab & OT Technician, Housekeeping in-charge, Pharmacist, etc.[26]

Different countries use different practices for biomedical waste management. These practices seek to implement environmentally sound management (ESM) of hazardous waste or other waste, best environmental practices (BEP) and best available techniques (BAT) in accordance with the Basel and Stockholm conventions and relevant national regulations and requirements.[27]

There are different technology options available for biomedical waste, having its own advantages and disadvantages.[28]

- **Thermal Process:** utilize heat to disinfect
- **Autoclave & Microwave** - Low Heat System
- **Incinerator & Hydroclaving** - High Heat System
- **Chemical Process:** use chemical to disinfect
- **Irradiative Process:** exposes wastes to ultraviolet or ionizing radiation
- **Biological Process:** use of biological enzymes for biomedical waste treatment
- **Mechanical Process:** change the physical form of waste by compaction, shredding

There are separate sanitation workers for biomedical waste and solid waste who collect and transfer these wastes for further disposal and treatment. They use different colours like Yellow, Red, White, Blue bags, bins and containers for proper management of biomedical waste as per standard guidelines issued by the government. Different categories, segregation, treatment and disposal methods of biomedical waste are summarized in Figure 8.

These may be double- or triple-layered bags to ensure no leakage of waste materials here and there. Biomedical Waste (Management and Handling) Rules, 1998 specifies the label for Bio-Medical Waste Containers / Bags.[29] There is mandatory labelling of biomedical waste containers to identify for priority treatment and disposal as depicted in figure. It should be non-washable and prominently visible.[30]

8. Management of Biomedical Waste by Corporate Houses

Major corporate players operating in the Indian Bio-Medical Waste Management Market are Medicare Environmental Management Pvt. Limited, Synergy Waste Management Pvt. Limited, Biotic Waste Solutions Pvt. Limited, Maridi Eco Industries Pvt. Limited, SMS Water Graca BMW Pvt. Ltd., GreenTech Environ Management Pvt. Ltd., Medicare Environmental Management Pvt. Ltd., Greenzen Bio Pvt. Ltd., SMS Water Graca BMW Pvt. Ltd., Ramky Enviro Engineers Limited and others. Ramky Enviro Engineers provides biomedical waste management solutions to more than 30,000 healthcare establishments, having 21 biomedical waste facilities which handle COVID-19 biomedical waste over 13,000 tonnes per day.[31] They pick up the waste from the origin points, tag it and reach the final disposal point. The company is taking several initiatives like organizing digital webinars related to concerned issues, planting trees to protect the environment, regular sanitization work in rural and urban areas besides its regular work of waste management and training of all its employees. Greentech Environ Management Ltd. and Medicare are working in West Bengal and follow all guidelines in relation to waste management. They are collecting medical waste from different hospitals and health establishments.[32] Shakti Waste Management Company established Common biomedical Waste Treatment Facility (CBWTF) at Sonipat Haryana.[33] Biotic Waste Solutions Pvt. Ltd. proposed the following process flow of biomedical

Waste Category (Type)	Colour Code	Prescribed Treatment	Final Disposal
Human Anatomical Waste (human tissues, organs, body parts, fetus below viability period (as per Medical Termination of Pregnancy Act 1971, amended from time to time))	Yellow non-chlorinated plastic bag/bin	Incineration	Ash disposal in municipal landfill
Soiled Waste (items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs, discarded linen,mattresses,routine mask & gown, and bags containing residual or discarded blood and blood components)	Yellow non-chlorinated plastic bag/bin	Incineration	Ash disposal in municipal landfill
Expired or Discarded Medicines (Pharmaceutical waste like antibiotics, cytotoxic drugs including all items contaminated with cytotoxic drugs along with glass or plastic ampoules, vials etc.)	Yellow non-chlorinated plastic bag/bin	Incineration	Ash disposal in municipal landfill
Microbiology, Biotechnology and other Clinical Laboratory Waste (Blood bags, laboratory cultures, stocks or specimens of micro-organisms, live or attenuated vaccines, human and animal cell cultures used in research, industrial laboratories, production of biological, residual toxins, dishes and devices used for cultures)	Yellow non-chlorinated autoclave/ microwave/ hydroclave safe plastic bag/bin	Pre-Treatment to sterilize/disinfect on-site as per WHO Guidelines*; thereafter incineration	Ash disposal in municipal landfill

Contaminated (Recyclable) Waste (disposable items other than sharps like tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles and fixed needle syringes), vaccutainers (with their needle cut) and gloves)	Red coloured non-chlorinated bag/bin	Sterilisation followed by shredding	Registered or authorised recyclers
Metallic Waste Sharps (needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpel, blades)	White translucent puncture proof, leak proof, tamper proof containers	Autoclaving followed by shredding	Iron foundries or sanitary landfill or designated concrete waste sharp pit
Glass Waste (intact & broken) (Broken/discarded and contaminated glass including medicine vials and ampoules except those contaminated with cytotoxic wastes)	Blue puncture proof and leak proof boxes or containers	Disinfection/ sterilization	Recycler
Liquid waste	-	Pre-Treatment with Disinfectant/ 1-2% Hypochlorite Solution	Discharge in drains or ETP

Source: Manual on Biomedical Waste Management in Health-Care Facilities

Figure 8: Categories, Segregation, Treatment and Disposal Method of BW

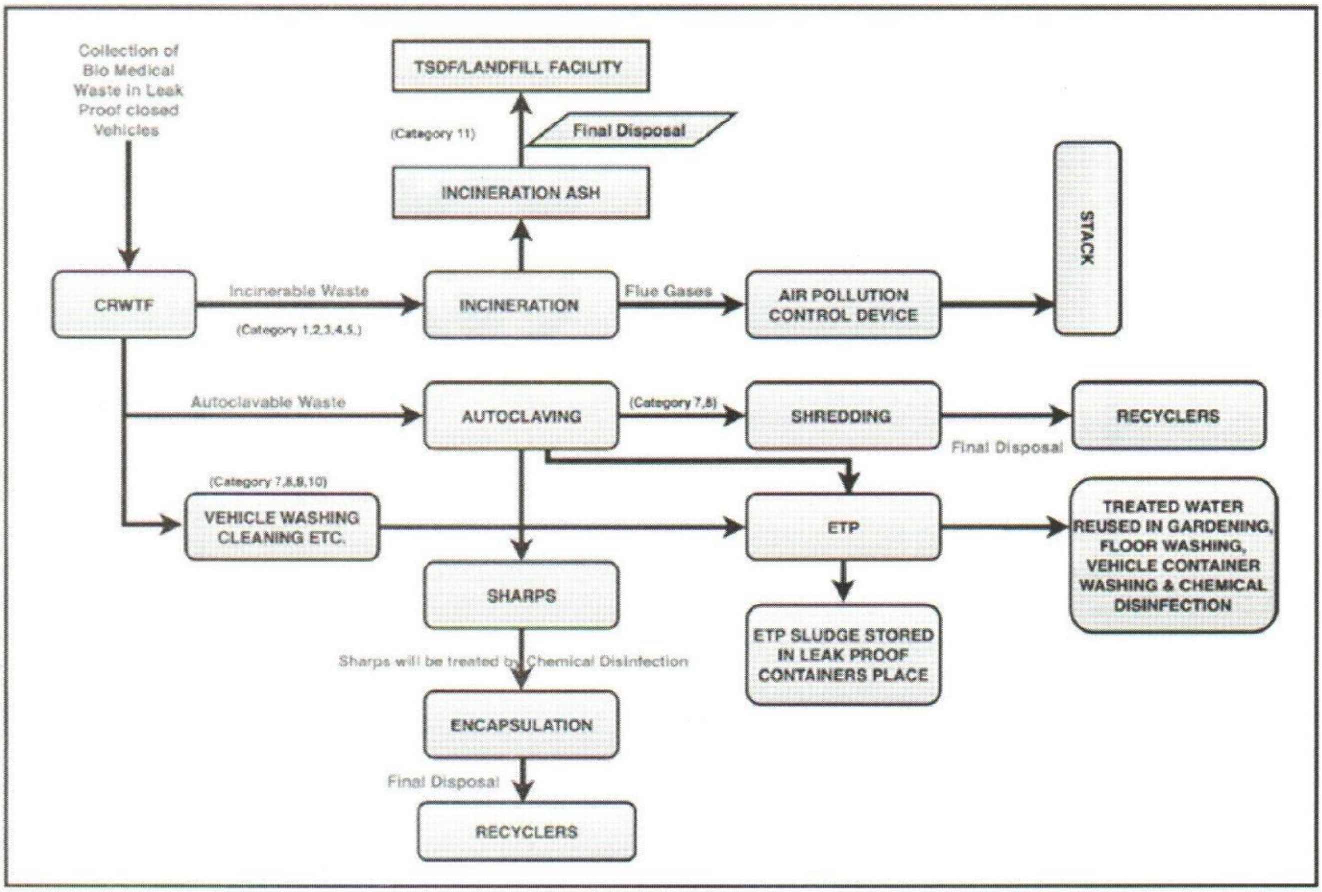
Source: Bio-medical Waste (Management and Handling) Rules, 1998

Figure 9: Label for Bio-Medical Waste Containers / Bags

Labelling	International symbols
« Danger ! Anatomical waste, to be incinerated or deeply buried »	
« Danger ! Contaminated sharps, do not open »	
« Danger ! Hazardous infectious waste »	
« Danger ! Highly infectious waste, to be pre-treated »	
« Danger ! To be discarded by authorized staff only »	 
« Danger ! Radioactive waste »	

Source: National Health-Care Waste Management Plan: Guidance Manual, WHO

Figure 10: Labelling of Biomedical Waste Containers



Source: Common Bio-Medical Waste Treatment Facility by M/s Biotic Waste Solutions

Figure 11: Process Flow of Biomedical Waste Management

waste management.[34]

9. Challenges in India

- Collection of all biomedical waste from origin point
- Proper segregation of biomedical waste
- Poor knowledge of collection, handling of waste
- Long distance from the origin point to the final medical waste disposal site
- Lack of formal training to sanitary workers and staff to handle the biomedical waste
- Less number of sanitary workers and staff to collect biomedical waste
- Difficulties in proper monitoring and verification
- Lack of knowledge about CPCB guidelines and BMWM rules among local people
- Lack of public awareness for the segregation of biomedical waste
- Cross contamination and disease transmission due to Illegal dumping by hospitals, nursing homes, clinics and other healthcare providers
- Protection and well-being of the staff at all times dealing with biomedical waste from different disease
- Inter-mingling of biomedical waste from other types of waste
- Increasing cost of collection and disposal
- High risk of unscientific disposal of the biomedical waste

10. Suggestions

- There must be proper and strict implementation of the rules, regulations and guidelines given by different authorities related to biomedical waste.
- These rules and regulations should not be limited to hospitals, nursing homes, healthcare provider institutions but should be applicable to individual

households.

- There should not be burial of biomedical waste by individual and they must incorporate best practices.
- Segregation at the time of waste generation must be practiced for proper management of waste.
- There is a strong need to create awareness at the local level about the current policies and guidelines about biomedical waste management and national protocols on water, sanitation and hygiene (WASH).
- We can host webinars on biomedical waste management to create awareness and engage the responsible persons. In relation to COVID-19, it is also very important to create awareness about safe use of incinerators and autoclaves as well as about adoption of appropriate health and safety measures.
- There is an urgent need for training of persons responsible for biomedical waste management at individual level.
- It is very important to follow social distancing protocols, and adopt all safety measures like mandatory use of personal protective equipment (PPE) by all staff members involved in collecting and disposing of the biomedical waste arising from the COVID-19.
- There must be sufficient numbers of incinerators to dispose of the medical waste by the hospitals in their premises and they must have necessary license and trained staff members to operate the incinerator.
- Government and other concerned agencies may provide Information, Education and Communication (IEC) materials on biomedical waste management free of cost at local level for community awareness.
- We have to ensure that biomedical waste should be packaged in double- lined, leak proof, tear-resistant, different colour bags, and kept separately in airtight containers and labelled accordingly.
- It should be mandatory to use disposable coveralls, footwear, boot covers, disinfectant sprays, face shields, masks, gloves, etc. by all the team members involved in waste management.
- The biomedical waste plant and all the equipment used in collection, storage, transportation and disposal like trolleys, storage bins, vehicles, etc. should be disinfected regularly.
- Separate routes for transporting hazardous and non-hazardous waste can be planned and used.
- Mobile biomedical treatment plants can be installed to manage the biomedical waste at appropriate places.
- Radio-frequency identification (RFID) can be used to track the volumes of waste and proper management to avoid dumping at local ground.
- Proper management of waste is a joint responsibility of central government, state government, local agencies, Common Bio-medical Waste Treatment Facility (CBWTF) and community also. The community must be equally responsible to manage any kind of waste.
- Biomedical waste must be disposed of in a scientific manner near production sites. Hospitals, health provider organizations and institutions may outsource biomedical waste management as per government guidelines.
- Biomedical waste management companies may use alternate solutions like use of Sterilwave machines & equipment and microwave technology.
- There is a strong need for strict monitoring to ensure effective management of biomedical waste.
- We can impose fine to the polluter if they have the lion's share in polluting the environment according to Polluter Pays Principle.
- As per law, Recycling Vending Machines, or Reverse Vending Machines (RVMs) can be installed at different places which accept empty beverage containers like bottles, cans, etc. for recycling purpose and it returns money to the people.
- Different types of recyclable waste must be sent directly to respective recycling facilities like paper waste can be sent directly to paper mills. It will help us to treat different types of waste easily. Further, we require a smart collection system and transportation to reach the final destination.

Conclusion

We may conclude that we must view 'biomedical waste' as a valuable 'resource' so that we can create wealth by converting it into useful products and energy. It is very essential to find out the innovative solutions for effective biomedical waste management. We have to understand the problems at grass root and find out the ways to meet the challenges of biomedical waste management. More and more companies must come forward and invest in "Waste to Wealth business". On the one hand, they will protect the environment and human wellbeing by managing the waste, other hand, they will provide the opportunities for employment and enhance economic activities. Different initiatives and programmes are required from the Central and State government ends, at all levels—for the community and corporate world—so that they can convert the biomedical waste into useful resources. Government must encourage the companies to set up the waste to wealth business and provide certain benefits to them. Due to lack of knowledge, most of the manufacturers are not thinking about waste to wealth business. Special training can be provided to them about how to use waste as an input material for new production.

Notes

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Economics is everywhere, and understanding economics can help you make better decisions and lead a happier life.

– Tyler Cowen

Assessing Customer as a Key in Resource Management for Measuring Productivity of Financial Services-A Comparative Study of SBI & HDFC BANKS

SEBASTIAN T. JOSEPH AND ABHISHEK JANVIER FREDERICK

The success or failure of an organisation is based upon the management of resources available to it, hence services rendered to the customers of a services-based unit plays a pivotal role in the existence of that unit. It becomes more crucial if the unit provides financial services. Financial services are the act of financial intermediaries to the households in a financial system, which involves different kinds of organisations that come together and work in synchronisation. These divergent organisations offer their expert opinion to cater the tapped or untapped market; by offering either the existing services or developing all together new services i.e. customised services for a specific set of potential customers. Organisations, for success in the market, mainly focus on men, material, and machines as resources for converting input into output. But technology has given the customers a tool to respond more aggressively towards the product and services offered; therefore, firms have to consider customers also as a new resource for themselves, especially in the service sector.

The present study aims to assess customer as a key in resource management for the efficacy of financial services offered by SBI and HDFC Bank.

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Introduction

In a product-based organisation, resources are utilised under a process for converting such resources into a product. But in the case of service-based industry, it is very difficult to assess the customer's satisfaction due to the absence of standards for fixing the quality of services in a tangible form. Therefore, the response from customers in actual moment of truth plays an exemplary role. We have seen many companies failing due to the absence of non-consideration of customers' responses.

In the field of service sector, it is unavoidable to ignore the customers' response as there are very few customers who take the pain to actually report problem in the service delivery system; while others simply switch to their competitors (Jerger & Wirtz, 2017). The term "financial services" became more prevalent in the United States partly as a result of the Gramm-Leach-Bliley Act of the late 1990s, which enabled different types of companies operating in the US financial services industry at that time to emerge. (Bill Summary & Status, 2012)

In India, the financial services are generally avoided by the moneylenders since the pre-British days and also while during their rule over India. These moneylenders used to provide money to peasants for purchasing seeds, manure, cattle in exchange of some security which may be land deeds or any other valuables, and in return, charged interest on the money lent.

Financial services are an essential component of any financial system through which the financial institutions render their services to the households of an economy. Financial system is an arrangement for transferring money from the borrowers to the savers in an economy where the borrowers pays a charge, generally known as interest, and the saver earns a premium amount over the savings, which he has transferred to the mediator for this arrangement.

A financial system can function on all the three levels i.e., global, regional or firm-specific level. Guruswamy, in *Financial Services and Systems,* has deliberated it as "a set of complex and closely interconnected financial institutions, markets, instruments, services, practices, and transactions" (Guruswamy, 2008).

Efficacy of Financial Services in Banks

Banks are the tool through which various financial services are offered to the households of an economy. The financial services are offered by the financial intermediaries after getting prior permission and licence from the financial regulators.

Efficacy of financial services rendered by the banks has been a major issue for the policy makers and policy planners, since the gains of real sector economy depend on how efficiently the financial sector performs the function of financial intermediation (Rangarajan, 1997). Efficacy of banks depend on factors such as employee satisfaction and customer satisfaction.

Service Quality Defined

Service, how one should define it, is it transferring value from one person to another by involving men, machine, method or material, by which can one say that he has received a good quality of services.

As we know from earlier research, customers do not perceive as a uni-dimensional concept, that is, customers' assessments of quality include perceptions of multiple factors (Valarie & Ziethmal, 1993). Service quality has multiple dimensions for different goods & services, for example, consumer goods, white goods and services etc. (Parasuraman, 1988) had focused after a considerable amount of research efforts on 5-dimensions in their assessments of service quality as given below:

1st Dimension—Reliability

It means the ability to perform the promised service dependably and accurately.

2nd Dimension—Responsiveness

Willingness to help customers and provide prompt service.

3rd Dimension—Assurance

Employees' knowledge and courtesy, and their ability to inspire trust and confidence.

4th Dimension—Empathy

Caring, individualised attention given to customers.

5th Dimension—Tangibility

Appearance of physical facilities, equipment, personnel & written materials.

The above dimensions represent how consumers organise information about service quality in their minds. On the basis of exploratory and quantitative research, these five dimensions were found relevant for banking too.

Banking Efficacy

Banking efficiency is also related to the macroeconomic environment such as monetary policy, structure of interest rate, capital/deposit mobilisation, credit policy and bull and bear market conditions. These policies and conditions influence the entire economy, banks and their efficiency. Basically, Indian banks are efficiently inefficient. In the Indian banking sector, till the 80s, the banks were operated in a highly regulated, protective and stressed environment.

Customers' Satisfaction in Financial Services

Indian banking sector has experienced the full cycle beginning from pure private players before Independence until the year 1972 which brought the nationalisation of banks, and once again the opening of banking sector for private players after the New Economic Policy of 1991.

I. Research Objective

To assess productivity of financial services offered by SBI and HDFC bank in relation to customers' satisfaction.

Hypothesis

Null Hypothesis H_{01} There is no significant difference between productivity of financial services offered by SBI and HDFC bank in relation to customer's satisfaction.

Alternate Hypothesis H_{01} There is a significant difference between productivity of financial services offered by SBI and HDFC bank in relation to customer's satisfaction.

II. Literature Survey

- (Bedi, 2010), the study attempts to find out is there any relationship between service quality, overall customer satisfaction and behavioural intentions across public and private banks in India. Later, the findings indicated that service quality is a significant determinant of customer satisfaction in Indian banking industry, irrespective of public or private sector banks. The study revealed that there are seven quality dimensions which influence customer satisfaction.

- (Pandit C, 2011), the study focused to understand the ICICI and SBI customers' perception towards services rendered by both the banks. Many attributes such as cooperation & behaviour of staff, ATM services, basic facilities, cheque collection time etc. were considered. The study revealed that ICICI bank is much ahead of SBI bank in providing quality services to their customers.

- (Adke & Dhande, 2011), the study focuses on the role of customer relationship management in banking sector and its need to increase customer value. The findings revealed that there is need of constant innovation in retail banking. For alluring the untapped market share of tomorrow, a paradigm shift in bank financing through innovative products and mechanisms involving constant upgradation and revalidation of banks internal systems and processes is urgently required.

- (Tooraj & Atefeh, 2011), the study focuses to find out the customers' understanding in the light of five dimensions of service quality, by majorly focusing on the gap No. 5 in gap analysis model. To know this gap, a study was conducted to investigate the quality of banking services on the level of Eghtesad-e-Novin Bank. It was found that the level of service quality rendered to the customers was more than the customers' expectations.

- (Mylonakis, 2009), the study emphasises that a majority of customers are satisfied with their banks whereas most of the bank customers believe that the use of new technologies will helps them in communicating with banks. They trust the bank employees for obtaining information on the existing banking products and services; while for new programmes, they prefer to choose alternative channels such as Internet, phone services, brochures and press releases.

- (Avtgis, 2000) concluded that people who reported increased communication and high reward in communication also reported greater relational satisfaction and greater perceived organisational influence.

- (Bennett & Durkin, 2002), customers' satisfaction can be enhanced if the employees are empowered. The employees should be clear about their discretion in solving the problems, remove conflicts and ambiguities, and take such actions which are in the best interests of the bank and customers.

- (Yagil, 2006) focuses on the relationship between employee empowerment and customer satisfaction in the banking sector. The result shows that employee empowerment and customer satisfaction have a positive relation between them. He further concludes that empowerment affects the employees' sense of control and attitude towards the service. Finally, empowerment has a favourable effect on the employees' performance and customer satisfaction.

III. Research Methodology

The core objective of the study is to do a comparative analysis of the productivity between SBI and HDFC Bank's financial services offered, in respect to customers' satisfaction, through measuring the factors on which efficacy of financial services are dependent.

Research Design

Exploratory Research design has been used in the study for measuring the efficacy of financial services.

Data used

Spade work has been done by the primary data on which the building of research had been erected with secondary data contributing as the labour.

Data Source

In this regard, primary data for measuring the satisfaction level has been collected from the customers and employees of SBI and HDFC bank.

Sample Size

The sample size for the study is considered 500 as the population was infinite and parameters, when the estimate is 5 per cent at 95 per cent confidence level.

The sample size for primary data is 500 out of which customers for SBI and HDFC Bank are 250 each.

Sampling Plan

The data had been collected from the bank ATMs at different locations of the city, and also by visiting different branches of the sample banks.

Data Collection Method

Primary data has been collected from the customers with the help of structured questionnaire having both open- and close-ended questions; the researcher has personally interviewed the customers and employees of SBI and HDFC Bank, and requested them to record their response on the questionnaire.

Data Collection Tool

The data has been collected by the researcher on the Questionnaire which has been used in previous studies also, for measuring the efficacy of banks.

Questionnaire for customers was developed by Barbara Culiberg, University of Ljubljana & Ica Rojšek, University of Ljubljana, which is administered at the Retail Banking sector in Slovenia, Europe (Barbara & Rojšek, 2010).

The questionnaire focuses on six service quality factors such as reliability, responsiveness, assurance, access, empathy and tangibility. The sum of all six factors lead to overall performance of the bank's service which ultimately lead to customer satisfaction.

Reliability

The questionnaire's reliability has been measured with the help of split half method which came to 0.81495409 for customer's questionnaire. Thus, indicating there is a positive correlation between the X and Y variables.

IV. Results & Findings

- Table 1.1 shows that there were about 88 per cent male respondents for HDFC customers and 82 per cent male respondents for SBI.
- Table 1.2 shows that the highest Per centage of 30.8 per cent respondents belong to the age group of 25–35 years at SBI, whereas in HDFC, merely 6 per cent respondents belong to the age group of 25–35 years.
- Table 1.3 shows that the highest Per centage of 39.2 per cent respondents for SBI belong to INR 3,00,001–8,00,000 income per annum whereas for HDFC 50.8 per cent respondents belong to INR 8,00,001–15,00,000 income per annum.
- Table 1.4 shows that about 59 per cent respondents were professionals in SBI, whereas only 16 per cent respondents were professionals in HDFC; about 17 per cent respondents were students in SBI whereas merely 6.4 per cent respondents were students in HDFC.
- Table 1.5 shows that, among the respondents, 20.8 per cent of SBI respondents were graduates and 58 per cent were postgraduates; whereas 30.4 per cent of HDFC respondents were graduates and 59.2 per cent were postgraduates.
- As per Figure 1.1, satisfaction level of HDFC customers towards reliability of services offered to them is more as compared to SBI customers which is evident by the results that 92.4 per cent HDFC employees responded that they are satisfied, whereas only 89.2 per cent customers responded that they are satisfied from the reliability factor at SBI.
- As per Figure 1.2, the responsiveness factor of the satisfaction level of SBI is less as compares to HDFC Bank. At SBI, 70.8 per cent employees responded that they were satisfied from the responsiveness factor while at HDFC, 84 per cent employees responded that they were satisfied.
- As per Figure 1.3, the satisfaction level of HDFC customers towards assurance of services offered to them is more as compared to SBI customers which is evident by the results that 97.2 per cent HDFC customers responded that they are satisfied whereas only 86.4 per cent SBI customers responded that they are satisfied.
- As per Figure 1.4, the access factor of services the satisfaction level of SBI is less as compared to HDFC. At SBI, 85.6 per cent customers responded that they were satisfied from the access factor while at HDFC 94 per cent customers responded that they were satisfied from the access factor.
- As per Figure 1.5, surprisingly, the satisfaction level of customers towards the empathy factor at both the banks is equal, as both the bank customers' responses show that 80.4 per cent customers had experienced that the employees were empathetic towards them while providing services.
- As per Figure 1.6, the satisfaction level of HDFC customers towards tangibility of services offered to them is more as compared to SBI customers, which is evident by the results that 98.4 per cent HDFC customers responded that they are satisfied whereas 86.8 per cent SBI customers responded that they are satisfied from the tangibility factor of services at bank.

V. Conclusion

For reaching to the overall customers' satisfaction of SBI and HDFC bank, all the factors affecting satisfaction of customers has been summed up, then its mean has been calculated.

The factors which have been summed up were:

- Reliability
- Responsiveness
- Assurance
- Access
- Empathy and
- Tangibility

The Figure 1. 7 shows that customers of HDFC Banks are more satisfied than the customers of SBI, as in the case of HDFC bank 52.8 per cent customers responded that they are very satisfied and 44.8 per cent responded that they are somewhat satisfied with their bank; whereas 23.6 per cent of SBI customers responded that they are very satisfied in comparison to HDFC and 64.8 per cent responded that were somewhat satisfied with the bank.

From the above analysis, it can be concluded that SBI customers are more satisfied compared to HDFC customers.

Therefore, both the companies should work more on improving the customers' satisfaction level. Especially, they should focus on the senior citizen's segment of their customer base.

The critical value of z calculated is 0.84557982 which is less than z distribution table value which is –or + 1.96, hence Null Sub Hypothesis1 is rejected and alternate is accepted.

H_{01} There is a significant difference between productivity of financial services offered by SBI and HDFC bank in relation to customer's satisfaction.

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Our progress as a nation can be no swifter than our progress in education. The human mind is our fundamental resource.

– John F. Kennedy

Appendices

DEMOGRAPHIC PROFILE OF CUSTOMERS

Table 1.1: Gender distribution of customers

Gender					
		SBI		HDFC	
		Frequency	Per cent	Frequency	Per cent
Valid	Male	205	82	218	87.2
	Female	45	18	32	12.8
	Total	250	100	250	100

Source : Self Calculated

Table 1.2: Age distribution pattern of customers

Age					
		SBI		HDFC	
		Frequency	Per cent	Frequency	Per cent
Valid	Below 25	51	20.4	51	20.4
	25–35	77	30.8	15	6
	36–45	56	22.4	89	35.6
	46–55	36	14.4	47	18.8
	56–65	21	8.4	45	18
	Above 65	9	3.6	3	1.2
	Total	250	100	250	100

Source : Self Calculated

Table 1.3: Income level of customers

Income					
		SBI		HDFC	
		Frequency	Per cent	Frequency	Per cent
Valid	<1,00,000	43	17.2	17	6.8
	1,00,001–3,00,000	26	10.4	13	5.2
	3,00,001–8,00,000	98	39.2	52	20.8
	8,00,001–15,00,000	47	18.8	127	50.8
	15,00,001–25,00,000	26	10.4	21	8.4
	>25,00,000	10	4	20	8
	Total	250	100	250	100

Source : Self Calculated

Table 1.4: Occupation of customers

Occupation					
		SBI		HDFC	
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Employee	28	11.2	94	37.6
	Businessmen	33	13.2	100	40
	Professional	147	58.8	40	16
	Student	42	16.8	16	6.4
	Total	250	100	250	100

Source : Self Calculated

Table 1.5: Education level of customers

Education					
		SBI		HDFC	
		Frequency	Per cent	Valid Per cent	Per cent
Valid	10^{th}	24	9.6	11	4.4
	12^{th}	29	11.6	15	6
	Graduate	52	20.8	76	30.4
	Postgraduate	145	58	148	59.2
	Total	250	100	250	100

Source : Self Calculated

Table 1.6: Reliability of HDFC

HDFC					
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	27	10.8	10.8	10.8
	Very Satisfied	117	46.8	46.8	57.6
	Somewhat Satisfied	87	34.8	34.8	92.4
	Somewhat Dissatisfied	10	4.0	4.0	96.4
	Very Dissatisfied	8	3.2	3.2	99.6
	Extremely Dissatisfied	1	.4	.4	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

Table 1.7: Reliability of SBI

SBI					
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	5	2.0	2.0	2.0
	Very Satisfied	74	29.6	29.6	31.6
	Somewhat Satisfied	144	57.6	57.6	89.2
	Somewhat Dissatisfied	27	10.8	10.8	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

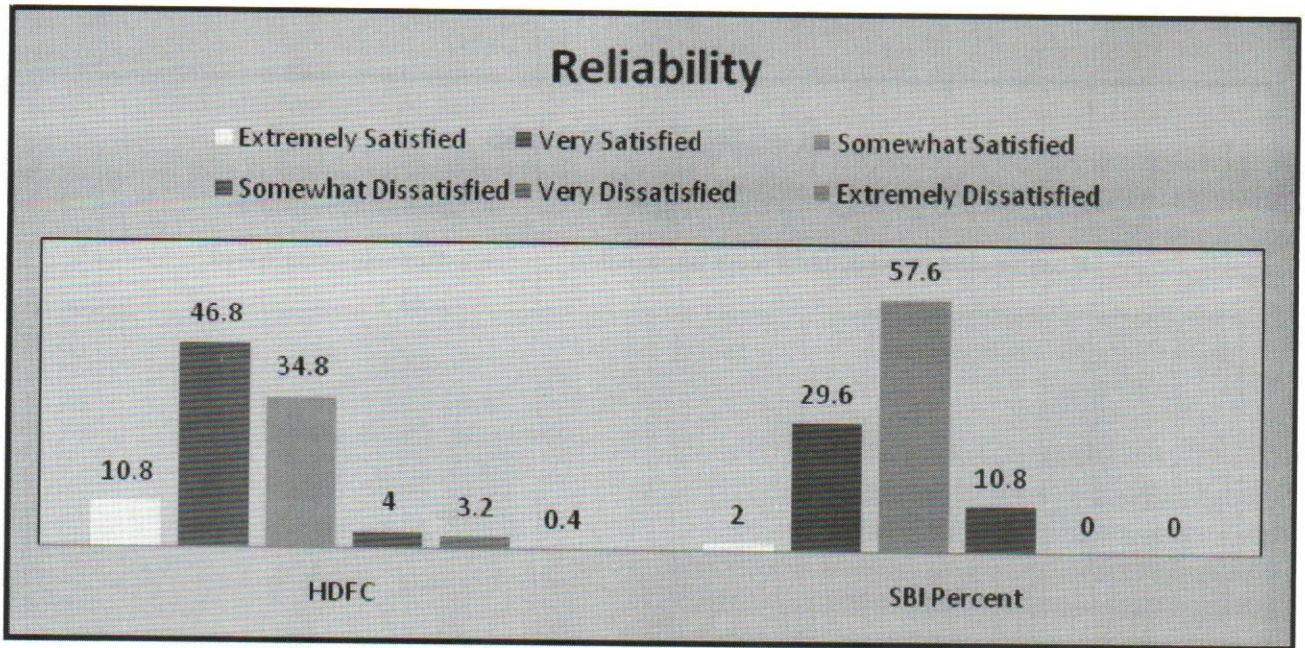

Figure 1.1: Reliability

Table 1.8: Responsiveness HDFC

HDFC					
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	12	4.8	4.8	4.8
	Very Satisfied	90	36.0	36.0	40.8
	Somewhat Satisfied	108	43.2	43.2	84.0
	Somewhat Dissatisfied	37	14.8	14.8	98.8
	Very Dissatisfied	3	1.2	1.2	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

Table 1.9: Responsiveness SBI

		HDFC			
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	3	1.2	1.2	1.2
	Very Satisfied	62	24.8	24.8	26.0
	Somewhat Satisfied	112	44.8	44.8	70.8
	Somewhat Dissatisfied	62	24.8	24.8	95.6
	Very Dissatisfied	10	4.0	4.0	99.6
	Extremely Dissatisfied	1	.4	.4	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

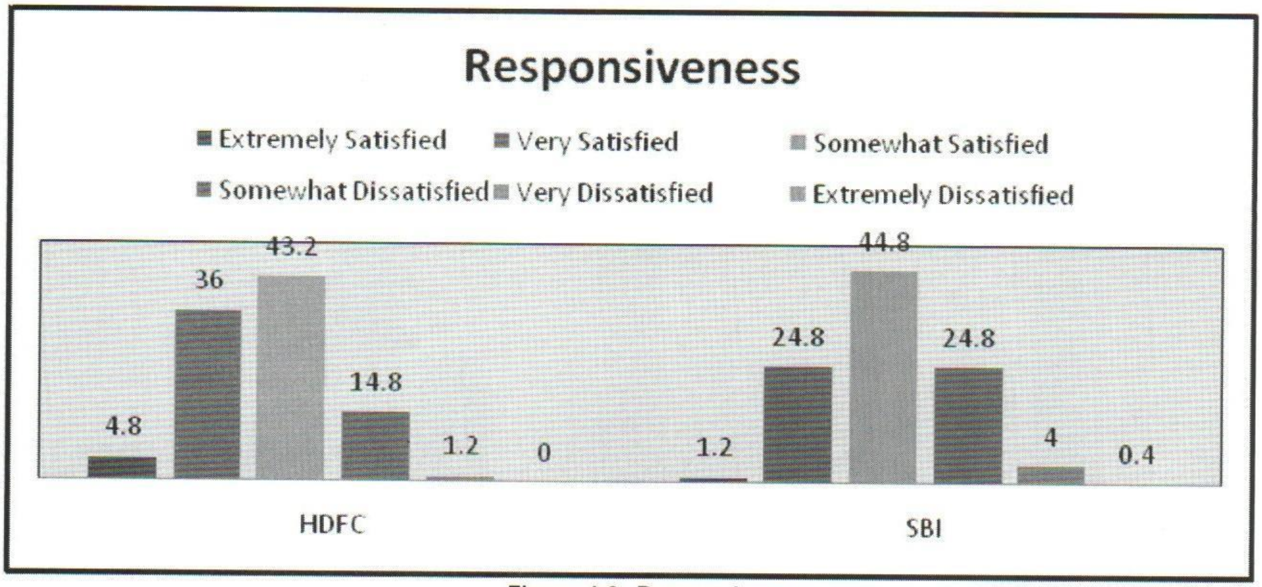

Figure 1.2: Responsiveness

Table 1.10: Assurance HDFC

		HDFC			
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	8	3.2	3.2	3.2
	Very Satisfied	187	74.8	74.8	78.0
	Somewhat Satisfied	48	19.2	19.2	97.2
	Somewhat Dissatisfied	6	2.4	2.4	99.6
	Very Dissatisfied	1	.4	.4	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

Table 1.11: Assurance SBI

		HDFC			
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	14	5.6	5.6	5.6
	Very Satisfied	97	38.8	38.8	44.4
	Somewhat Satisfied	105	42.0	42.0	86.4
	Somewhat Dissatisfied	32	12.8	12.8	99.2
	Very Dissatisfied	2	.8	.8	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

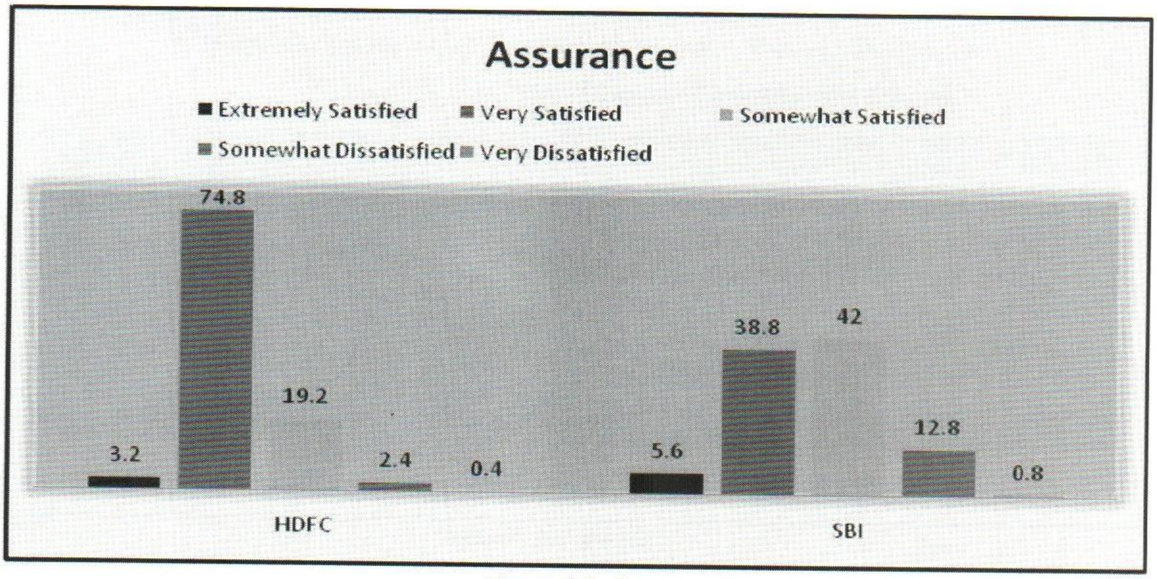

Figure 1.3: Assurance

Table 1.12: Access HDFC

		HDFC			
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	30	12.0	12.0	12.0
	Very Satisfied	120	48.0	48.0	60.0
	Somewhat Satisfied	85	34.0	34.0	94.0
	Somewhat Dissatisfied	14	5.6	5.6	99.6
	Very Dissatisfied	1	.4	.4	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

Table 1.13: Access SBI

SBI					
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	21	8.4	8.4	8.4
	Very Satisfied	105	42.0	42.0	50.4
	Somewhat Satisfied	88	35.2	35.2	85.6
	Somewhat Dissatisfied	28	11.2	11.2	96.8
	Very Dissatisfied	8	3.2	3.2	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

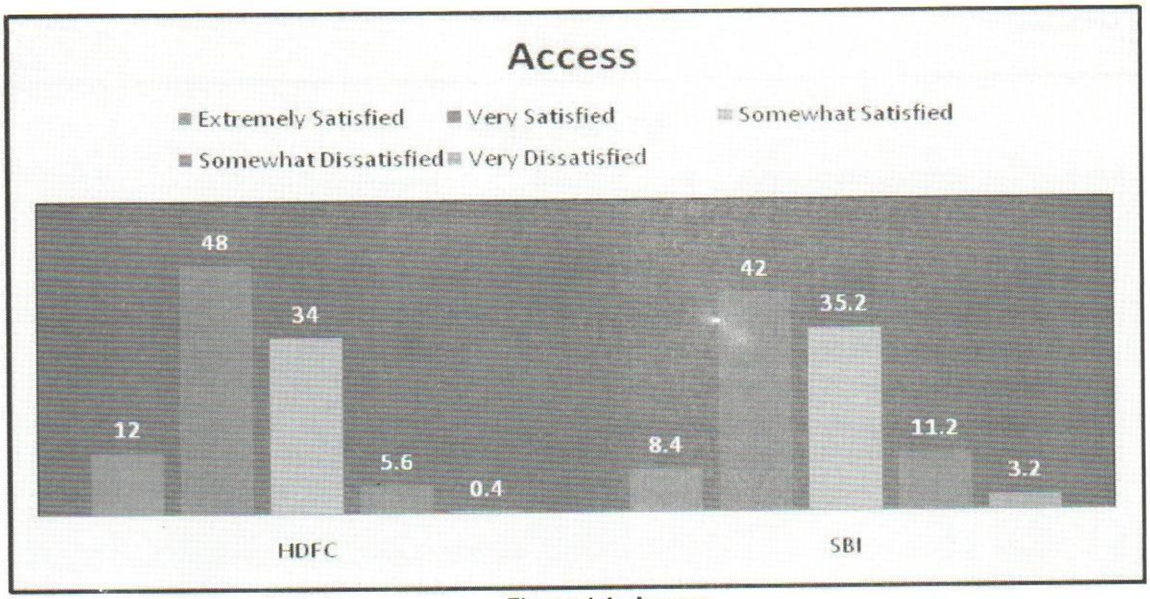

Figure 1.4: Access

Table 1.14: Empathy HDFC

HDFC					
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	16	6.4	6.4	6.4
	Very Satisfied	110	44.0	44.0	50.4
	Somewhat Satisfied	75	30.0	30.0	80.4
	Somewhat Dissatisfied	37	14.8	14.8	95.2
	Very Dissatisfied	9	3.6	3.6	98.8
	Extremely Dissatisfied	3	1.2	1.2	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

Table 1.15: Empathy SBI

SBI					
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	13	5.2	5.2	5.2
	Very Satisfied	86	34.4	34.4	39.6
	Somewhat Satisfied	102	40.8	40.8	80.4
	Somewhat Dissatisfied	41	16.4	16.4	96.8
	Very Dissatisfied	8	3.2	3.2	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

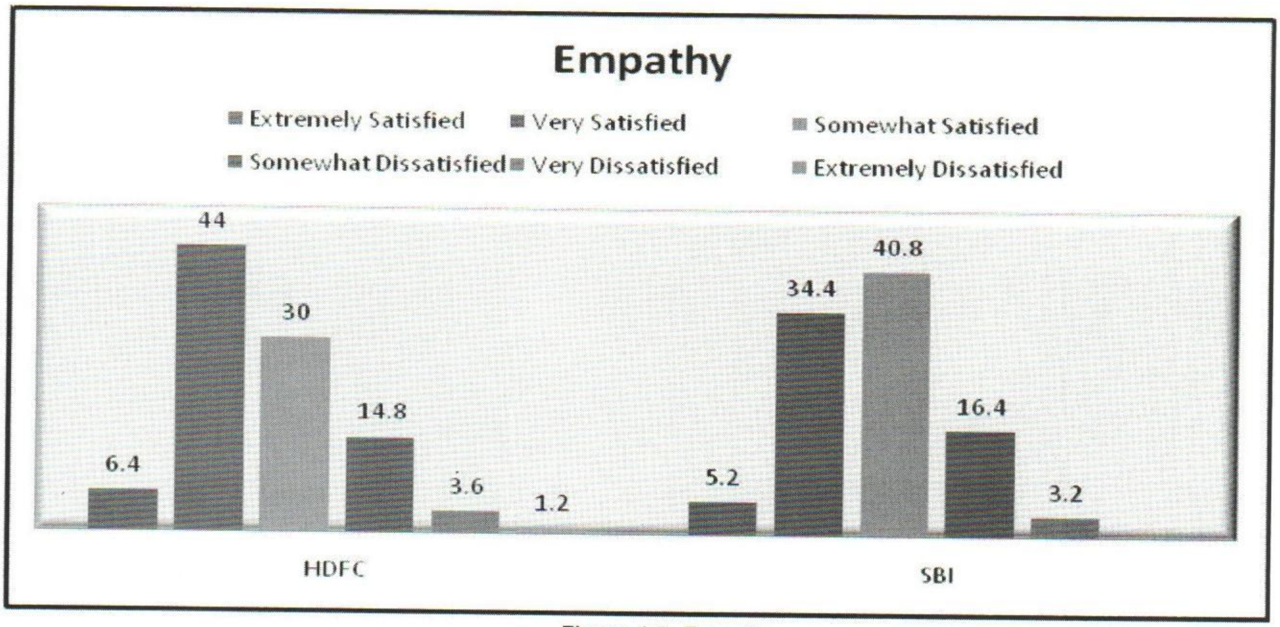

Figure 1.5: Empathy

Table 1.16: Tangibility HDFC

HDFC					
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	11	4.4	4.4	4.4
	Very Satisfied	196	78.4	78.4	82.8
	Somewhat Satisfied	39	15.6	15.6	98.4
	Somewhat Dissatisfied	3	1.2	1.2	99.6
	Very Dissatisfied	1	.4	.4	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

Table 1.17: Tangibility SBI

SBI					
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	12	4.8	4.8	4.8
	Very Satisfied	100	40.0	40.0	44.8
	Somewhat Satisfied	105	42.0	42.0	86.8
	Somewhat Dissatisfied	29	11.6	11.6	98.4
	Very Dissatisfied	4	1.6	1.6	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

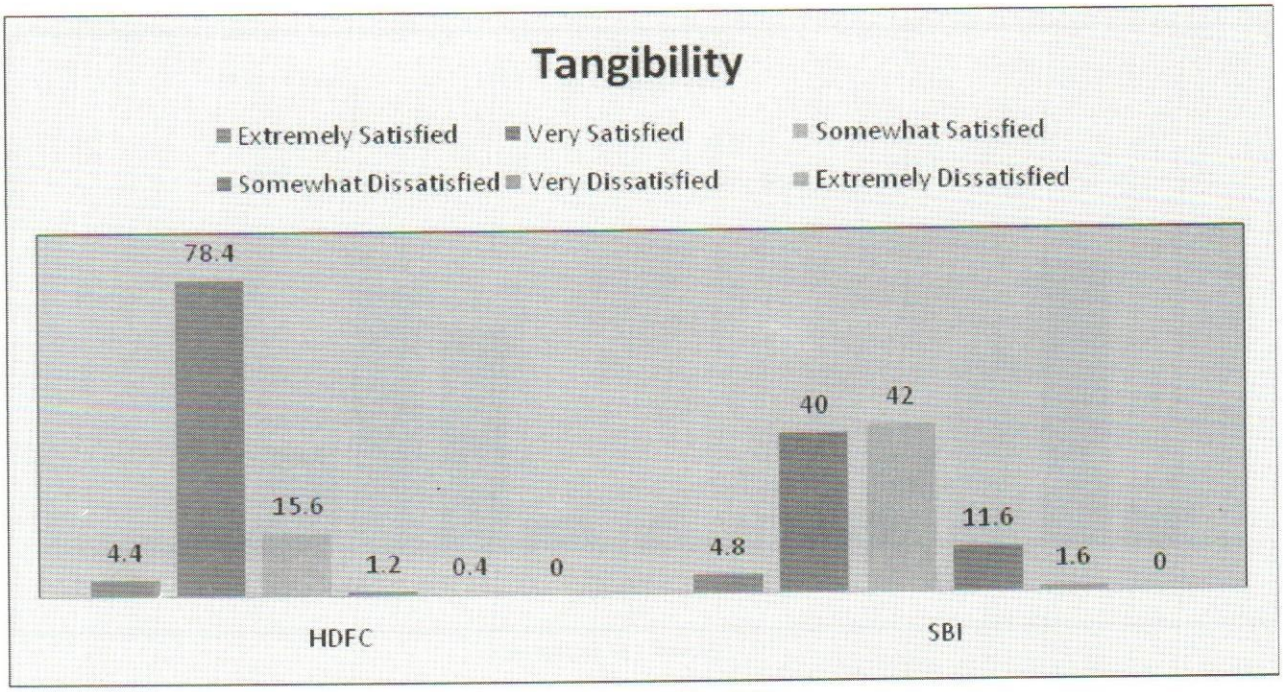

Figure 1.6: Tangibility

Table 1.18: SBI Customer Overall satisfaction

SBI					
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Extremely Satisfied	1	.4	.4	.4
	Very Satisfied	59	23.6	23.6	24.0
	Somewhat Satisfied	162	64.8	64.8	88.8
	Somewhat Dissatisfied	28	11.2	11.2	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

Table 1.19: HDFC Customer Overall satisfaction

HDFC					
		Frequency	Per cent	Valid Per cent	Cummulative Per cent
Valid	Very Satisfied	132	52.8	52.8	52.8
	Somewhat Satisfied	112	44.8	44.8	97.6
	Somewhat Dissatisfied	5	2.0	2.0	99.6
	Very Dissatisfied	1	.4	.4	100.0
	Total	250	100.0	100.0	

Source : Self Calculated

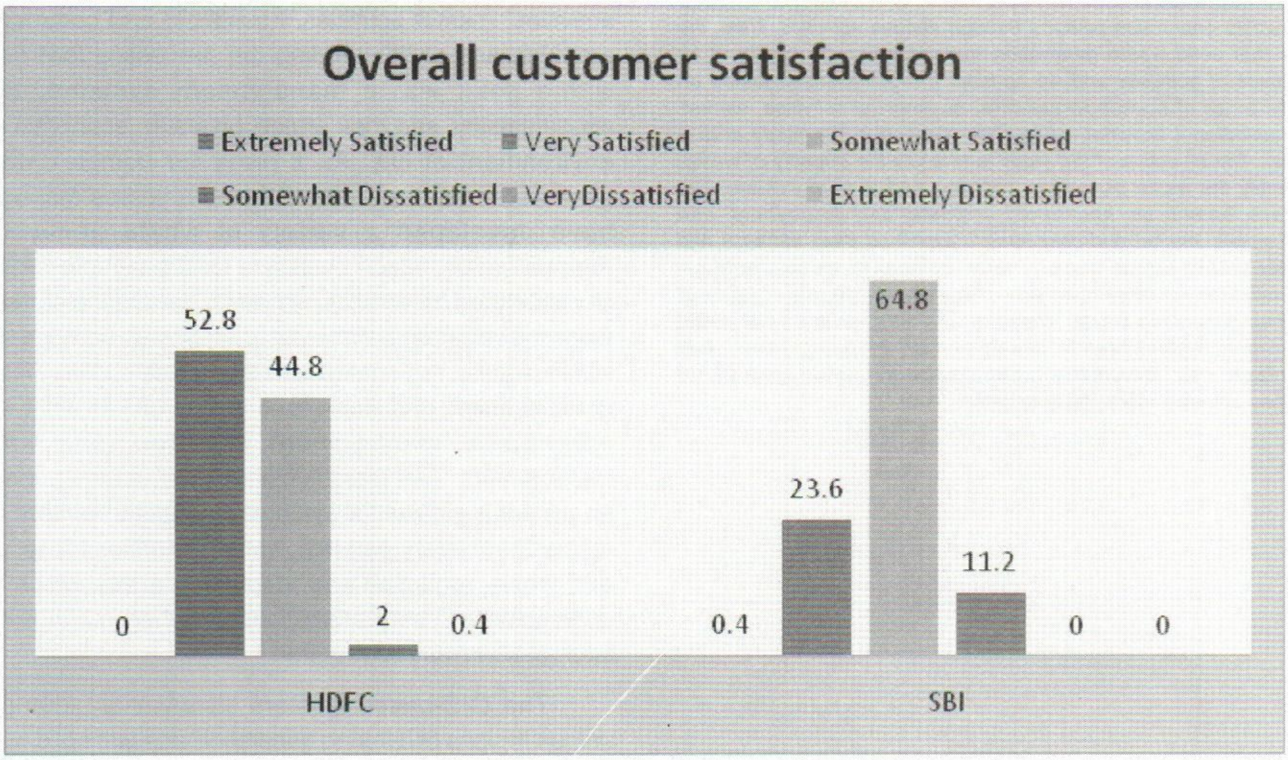

Figure 1.7: Overall Customer Satisfaction

Focus

GIS-mapped Solid Waste Generation Clusters Capture Eco-friendly Waste Management Practices

T. DHANALAKSHMI

Waste generation regionalization delineates areas of similar types of wastes, quantity of waste, and activities generating wastes provide a basis for systematic solid waste management. Advances in Geographical Information System and big data analysis approaches, provide new opportunities for regionalization, especially in terms of solid waste generation patterns through various activities. Here, we show that solid waste generation dynamics can be captured by Dynamics of activities and we conduct a regionalization based on the dynamics of household activities, commercial activities, market, and institutional activities using GIS mapping in the study area—Cochin. The objective of the study is to know the quantity of waste, to identify the waste generation activities, and to form clusters. The clusters based on household, commercial, household and commercials, market and commercials explained more variance and greater within-region homogeneity, compared to conventional regionalization for large quantities of wastes irrespective of types of activities generating waste. These results suggest that solid waste generation regionalization based on GIS mapping have clear advantages over conventional regionalization for certain applications, and they are also more easily updated.

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1. Introduction

Solid waste generations are complex and variable over time and space, household activities, commercial activities, market activities, household and commercial activities and understanding the processes that occur within solid waste management systems, their accountability, and their effects on socio, economic and environment of city. As a proxy for complex waste generation variation, scientists and resource managers have developed a variety of waste generation regionalization, which classify a land base into regions characterised by similar solid waste generation patterns. Because conditions of interest are relatively homogenous within regions, regionalization can provide frameworks for generalization, and stratification, and indicate what is an appropriate management goal for solid waste management. This regionalization then, in turn, provides an underlying basis for systematic waste treatment and resource recovery patterns, setting priorities for recycle and waste reduction and identifying areas which are undergoing unusual perturbations and where management interventions may be required.

The GIS-based clusters successfully identified unique regions of differing generation rate and solid waste characteristics over the regions, capturing major waste generation activities such as the household, market, commercials, and institutions (Figure 1). Comparing the waste generation within each cluster, we found several distinct waste generation groupings. Concurrent with increases in computing resources, advances in GIS technology has increased the relevance of GIS mapping for solid waste generation studies. There are major benefits to the use of GIS mapping, which include master data allowing for consistent and synoptic monitoring, reduced cost, and ready access.

2. Review of Literature

Waste is generated in all areas, but there is a large variation in its type and quantity. According to R. K. Garg, (2002), the quantity and nature of the waste generated vary with the activities and the level of technological development in a country. "The issue of waste is not only because of the increasing quantities but also largely because of an inadequate management system." (E. Tinmaz & I. Demir., 2005). Nowadays, municipalities and Corporations are affected with inadequate management systems. Better management systems for waste not only requires waste generation but also requires information regarding variation in each cluster.

This study revealed that Kochi city generated about 250 tonnes of waste per day and on per capita basis it was 0.36 kg/day. He concluded that composting is the most suitable method for treatment of solid waste in Kochi since it consisted a considerable percentage of organic waste.

Based on the studies carried out by the Centre for Earth Science Studies and data compiled by Clean Kerala Mission for all the Municipalities and Corporations of the state, the average daily per capita generation comes to 0.178kg, with a very high variation from 0.034kg for Koothuparamba to 0.707kg for Thalassery (CESS, 2001; Padmalal and Maya, 2002).

Systematic analysis helps to chalk out appropriate remedies for solid waste management. GIS could help in dealing with several factors simultaneously which need to be considered while planning waste management. "GIS is a system of computer hardware and software, designed to allow users to collect, manage, analyze and retrieve large volumes of spatially referenced data and associated attribute data collected from a variety of sources." (S. Upasna & M. S. Natwat., 2003). The results arrived from GIS identified areas which generate more or a different category of waste. Also, there is a general categorization in the waste generation which helps to analyze waste generation trends. These trends are useful while planning waste management.

3. Objective of the Study

- To quantify the waste generated in the study area Cochin.
- To identify the activities generating solid waste
- To develop the clustering of waste generation activities

4. Data Sources and Methodology

- The Geographic Information System (GIS) has been used to analyze existing maps and data, to digitize the existing ward boundaries, and to enter the data about the wards and quantity of waste generated in each ward.
- The secondary data collected from the report of Kerala State Urban Development Programme have been used to study the quantity of municipal solid waste in the study area.

The cluster approaches used to evaluate the generation pattern of solid waste in the city are as follows:

- The information on quantity of waste generated by each ward has been collected from the Corporation of Ernakulam district. This is generated based on quantity of waste collected and transported on a day to day basis i.e., based on the number of trips made or on approximation by municipal agencies.
- The ward map of Corporation has been used to study the distribution of activities generating waste. The study identified only the waste generating activities based on the information provided in the map.
- The information on physical and chemical characteristics of solid waste have been gathered from the report of Kerala Sate Urban Development Programme.
- Generation of solid waste by different activities in each ward has been assessed by using primary and secondary data from Cochin Corporation and State Pollution Control Board. For example, the total waste in a Corporation included residential, commercial, and institutional wastes. The generation rate evaluates the concentration of waste within a given cluster defined by a particular activity. Higher the rate of waste generation, more acute is the pressure and concentration of waste in a given cluster.
- Clusters are formed based on the rate of generation of solid wastes. The generating pattern of solid waste in a study area depends on the activities generating waste. The generation rate for each ward is based on clearance of waste by local body.

5. Results and Discussions

5.1 Quantity of waste generated in Cochin

An effective management practice takes into consideration the type and quantity of solid waste generated by a particular region. The type of waste is defined on the basis of the activity that generates the waste. The quantity refers to the amount of waste generated by the activity. The generation pattern refers to type and quantity of waste produced by residential, industrial, commercial activities etc.

The physical composition of municipal solid waste is important for deciding the prime management actions namely the reduction, reuse, and recycling of waste. Table 1 represents the physical characteristics of solid waste. According to the Kerala State Urban Development Programme report, the chemical characteristics of municipal solid waste in Kochi are as follows: density-267.81kg/m3, moisture content-55.29 per cent, calorific value-1759K.cal/kg, pH-7.46, C-26.39 per cent, N-1.25 per cent, C/N-21.11 per cent, P as P2O5-129.25 per cent. The heavy metal content of municipal solid waste contains Ar-5.72Mg/kg, Ni-4.49ppm, Cd-0.38ppm, Pb-2.48ppm, Cu-47.53ppm, Zn-98.98ppm, and Hg <0.1Mg/kg.

The types and quantities of waste generated in Cochin are represented in Table 2.

5.2 Activities generating solid waste in Ernakulam

The factor that contributes to the major proportion of waste generation is population, population density, residential, commercial, industrial, and institutional activities. The activities identified as the main waste producers are residential, industrial, commercial, institutional, and bio medical institutions. Residential waste includes solid waste generated by population as well as waste generated through daily domestic and household activities. Industries, through their production processes, release certain amount of toxic and other solid wastes into the environment. Commercial and institutional activities also contribute to waste generation in the city. Bio medical waste is the solid waste generated by hospitals and other health institutions. The study about type and quantity of waste generated helps to understand the management system required for its safe and efficient disposal.

5.2.1 Population Distribution

The population of the city generates municipal solid waste. The estimation of quantity of residential waste generated by Cochin is based on the population distribution in Cochin Corporation. The increase in waste generation rate is closely associated with the increase in population in the city. Cochin city has a population of 677,381 according to 2011 census.

5.2.2 Density of population

Urban population density is the ratio of people per square km, gross or net. Density influences both policy and structural aspects in terms of ground and house congestion, when there is shortage in urban land area within a given range of accessibility to the city centre. The urban population density is the elements of urban form, the city size, age, and structure which changes in relation to land use, employment structure and socio-economic status of dispersal within the city. This emphasizes the importance of centrality or maximum accessibility in land use structure and patterns. The population densities decline from the city centre, regardless of time and place. As Berry et al., (1963) stated that "The competition for urban sites by different land users and differences in their abilities to pay, result in bid-rent functions of varying gradients with the highest value at the location of maximum accessibility. Thus, larger spaces at prime locations of higher accessibility are occupied by those with higher paying abilities. The residential users, therefore, occupy smaller proportion of land near the centre and larger proportions away from it. Here again, more people want to live near the centre due to its higher accessibility. However, as the land near the centre is more expensive, they consume little of it. Since land availability and extensive use increase with distance from city centre, population densities also decline with the distance. The factors influencing density in the city core and density gradients are many and changing-the age, size of residential lots, land use, centrality and central functions and transportation technology".

Accordingly, people with higher paying abilities living in city centre who generated more waste have higher accessibility for disposing waste. And clearance of waste by municipal services is better in city centre due to good infrastructure facilities when compared with other places which have narrow lanes with no infrastructure facilities. The higher the population density away from city centre to other areas, the more acute is the problem of solid waste management. The density of population in Cochin Corporation is 7139 persons/Sq.Km.

5.3 Activities generating solid wastes in the clusters

Waste is generated in all areas but there is large variation in its type and quantity. According to R. K. Garg, (2002), the quantity and nature of the waste generated vary with the activities and the level of technological development in a country. "The issue of waste is not only because of the increasing quantities but also largely because of an inadequate management system." (E. Tinmaz & I. Demir., 2005). Nowadays municipalities and Corporations are affected with inadequate management systems. Better management systems for waste not only requires waste generation but also requires information regarding variation in each ward.

Systematic analysis helps chalk out appropriate remedies for solid waste management. GIS could help in dealing with several factors simultaneously which need to be considered while planning waste management. "GIS is a system of computer hardware and software, designed to allow users to collect, manage, analyze and retrieve large volume of spatially referenced data and associated attribute data collected from a variety of sources." (S. Upasna & M. S. Natwat., 2003). The results arrived from GIS, identified areas which generate more or a different category of waste. Also, there is a general categorization in the waste generation which helps analyze waste generation trends. These trends are useful while planning waste management.

Figure (1) shows the regionalization map of 5 clusters with examples of fine-scale spatial patterning arrived with GIS mapping. Colours were discretely assigned (exactly 6 colours shown) based on each cluster's solid waste generation rate relative to all other clusters, as shown in the colour space legend. Blue areas indicate water bodies like canal and river, light yellow areas indicate waste generation rate of less than 1.00 tonne, dark yellow areas indicate waste generation rate of 1.0-2.0 tonnes, light orange areas indicate waste generation rate of 2.0 to 3.0 tonnes, and dark orange areas indicate the waste generation rate of 3.0 to 4.0 tonnes while dark brown colour areas indicte waste generation rate of more than 4.0 tonnes.

5.3.1 Generation of waste through household activities

Organic kitchen waste, paper and polyethene are generated by the household activities. The quantum of waste generated is calculated on the basis of population distribution in each ward. Increase in waste generation is closely associated with population and socio-economic factors of each ward. The relationship between household activities and waste generation shows that the higher is the rate of waste generation, more acute is the problem of solid waste management in the concerned cluster. Also, waste disposal is acutely felt along the narrow lanes and slums of the city due to lack of infrastructure facilities to clear the waste. So, the waste reaches open ground, roadsides, and waterways, which causes surface water pollution in city. Accordingly, people with higher paying abilities living in city centre who generated more waste have higher accessibility for disposing waste. And clearance of waste by municipal services is better in city centre due to good infrastructure facilities, when compared with other places which have narrow lanes with no infrastructure facilities.

Cluster 1

The cluster which contributes less than 1.0 tonne per day in Cochin Corporation is the result of low density of population and socio-economic factor. Also, the waste disposal is acutely felt in that cluster. Kunnumpuram, Ponekkara, Puthukkalavattam, Elamakkara North, Thattazham, Island North, Thevara, Edakochi, Thazhuppu and Katebhagam wards generate less than 1.0 tonne of waste per day.

Cluster 2

The cluster 2 which contributes 1.0 to 2.0 tonnes per day is the result of high density population and socio-economic factor. The quantum of waste generated in different wards within the Cochin Corporation is as follows: Vaduthala, Gandhi Nagar, Perumanoor, Island south, Puttardesham, Nambiapuram, Konam, Manasheri and Moolamkuzhi generated around 1.0–2.0 tonnes of waste per day, with higher paying abilities living in the city centre generated more waste when compared to others.

The problems related to solid waste generation and its disposal are acutely felt along the narrow lanes where slums are located. Lack of essential infrastructure for solid waste clearance in these regions is the main cause of the problem. In the absence of solid waste clearance infrastructure, the waste reaches the open ground, roadsides, and water ways. The slums are one of the important contributors to surface water pollution in city. The issue of night soil is also a contribution of slum dwellers as they do not have the essential infrastructure within the residential region. The waste generation of household activity relationship states that the higher the generation rate, more acute is the problem related to solid waste in the concerned cluster.

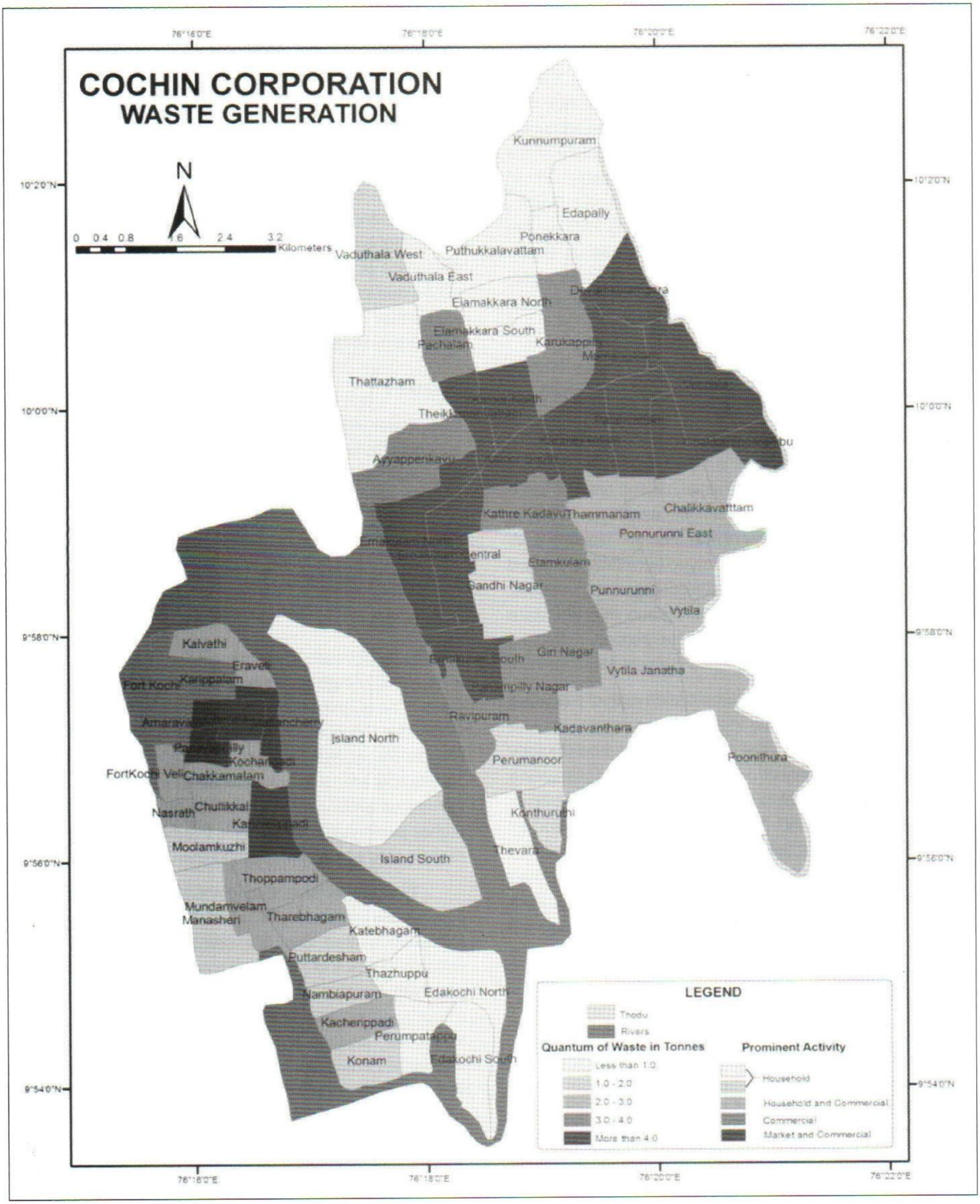

Figure : Activities generating solid waste in clusters

Cluster 3

5.3.2 Generation of waste through household and commercial activities

Waste generated through households and commercial activities are discussed here in cluster 3. The commercial activities in city include wholesale and retail markets catering to the consumption needs of population. The waste generated by this activity is referred to as commercial waste. These activities generated 2.0 to 3.0 tonnes of waste. Thammanam, Chalikkavattam, ponnurunni East, Vytila, Kadavanthara, Kacherippadi, Tharebhagam, Thoppampodi, Chullikkal, Chakkamattam, Panayapilly, Eraveli and Kalvathi wards of Cochin Corporation have high concentration of activities and generated 2.0 – 3.0 tonnes of waste per day.

Cluster 4

The category of mixed activities in map has been grouped under commercial sector for the study purpose. The mixed activities include commercial, industrial, institutional, and residential sectors. These activities generated 3.0–4.0 tonnes of waste per day. Waste generated by commercial establishments such as shops, restaurants, and offices, are collected together with household waste. The wastes generated from shops and commercial establishments are mainly recyclable in nature. Restaurants generate solid wastes such as paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes and hazardous wastes. Through recycling and waste reduction programs, the city can reduce their wastes. Institutional waste is the waste generated by schools, leisure facilities, hospitals (excluding clinical waste), etc. This is often included within the commercial waste category. A comparison of wastes generated in rural and urban areas shows no significant differences in the composition of the commercial waste generated. However, the quantity of commercial waste is comparatively high in densely populated urban areas.

Elamakkara South, Devamkulangara, Ayyappenkavu, Kathre Kadavu, Elamkulam, Giri Nagar, Ravipuram, Amaravathi, Fort Kochi and Karippalam wards of Cochin Corporation generated 3.0–4.0 tonnes of waste per day.

Cluster 5

5.3.3 Generation of waste through market and commercial activities

In cluster 5 Market and commercial activities generated more than 4 tonnes waste per day in the respective wards of Cochin Corporation. The vegetable shops/markets generate large quantities of degradable waste including dried plantain leaves used for wrapping agricultural goods. The commercial activities contribute to the maximum waste generation, in comparison with other activities, is a result of man's day to day domestic and commercial chores. Market cum commercial activities are prominent in Mamangalam, Vennala, Palarivattom, Chakkaraparambu, Karanekotam, Kaloor, Ernakulam North, Ernakulam central, Ernakulam south, Panampilly nagar, Karuvelipady, Kochangadi and Mattancherry wards and they generated more than 4.0 tonnes of waste per day.

5.3.4 Generation of waste through industrial activities

The most polluting industrial groups within the city are oil refineries, which are producing alkaline, BOD waste, Combustion products, emulsions, hydrocarbons, mucaptans, minerals, acid minerals, phenol, sulphides, sulphur, tar as waste products. The electroplating industries generate pollutants such as alkali, boron, cadmium, chromium, copper, detergent, fluoride, iron, nickel, organic complex agents, cyanide, phosphates, silver, sulphate etc. These hazardous wastes pose a severe threat to environment because of the toxicity. These are a danger to the existing environment and its resources. The effect of such a type of waste generation is adverse on the ecosystem and human health. The industrial and biomedical units in city contribute to hazardous waste generation. Among the industries, the most polluting ones are oil refineries, electroplating and service stations. The waste generated by these industries is toxic and hazardous in character. However, no proper disposal techniques are available for the industrial waste generation in the city.

Another type of hazardous waste generated in city is by bio-medical activity. Some of the waste generated by medical centres in the city is infectious in nature. The waste requires a safe mode of disposal, with least or minimum exposure to people.

5.3.5. Other activities—Bio medical waste generation

Even though these are insignificant in terms of distribution of activity, this point source generates waste. The infectious waste generated by this activity is hazardous in nature.

The other activities include vacant land and water bodies. The role of these activities in generation pattern of solid waste is insignificant.

6. Limitation of the study

The information was collected from different sources and incorporated in the GIS database. The limitations are discussed below. The maps available from the Corporation was old and do not have the information about the later date and changes.

Commercial and institutional solid wastes are important contributors to the waste handled by Corporation and Municipalities. With the exception of hospital wastes, little compositional data are available. There can be an analysis of physical and chemical characteristics of waste generated in the city. Since commercial and institutional wastes are often collected with domestic refuse by municipal agencies, such information would require special sampling and analysis efforts. This could help in analyzing the waste generation situation in a precise manner. Such tests have not been extensively conducted.

7. Conclusion

The generated ArcGIS maps give efficient information concerning static and dynamic parameters of the municipal solid waste management problem such as the generation rate and disposal of municipal solid waste in different clusters and their attributes. These clusters of solid waste generation activities help understand the acuteness of solid waste problem faced by the city. Such cluster analyses help to lay out an efficient management infrastructure for the clearance, transportation, and disposal of solid waste.

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The people have a vital interest in the conservation of their natural resources; in the prevention of wasteful practices.

– Herbert Hoover

Table 1: Physical composition of municipal solid waste

Type of municipal solid waste	Percentage of municipal solid waste
Paper	4.87
Plastic	4.83
Metal	0.35
Glass	1.06
Rubber & leather	1.50
Inerts	1.74
Ash and fine earth	1.68
Compostable organics	79.78
Domestic hazard	0.28
Others	3.91
Total	100

Source: Kerala State Urban Development Programme

Table 2: Waste generation activities in Cochin Corporation

Ward No.	Houses	Shops	Hotels/ Restaurants	Institutions	Hospitals	Thattukada	Markets Tonnes	Total waste
1	3200	270	35	8	0	42	1	3.75
2	2000	123	13	0	0	1	1	3
3	1750	66	7	0	1	0	0	3
4	2277	145	9	3	0	3	1	4
5	3492	422	16	5	1	4	1	6
6	1577	121	8	35	1	3	2	3
7	2405	282	9	60	2	4	0	5
8	3105	201	1	3	2	2	1	11
9	1048	137	7	32	1	3	0	3
10	2526	228	2	4	3	2	0	11
11	2450	688	19	2	4	1	2	3
12	2300	460	11	1	1	0	0	2.5
13	2800	160	5	2	0	0	0	1
14	2700	145	5	3	1	0	0	1
15	2100	51	4	3	1	10	1	0.75
16	2250	47	3	3	1	8	0	0.75
17	2100	35	5	3	0	7	1	1
18	2300	51	4	2	1	9	0	1.5
19	2400	106	4	0	1	11	1	2.5
20	2400	104	4	0	0	0	0	1.5
21	2500	127	7	3	1	0	1	1.5
22	2406	149	2	2	1	0	0	3
23	1702	24	0	2	0	0	0	2
24	1584	121	1	2	1	0	1	2
25	1480	58	4	2	0	0	0	3
26	2200	96	11	0	0	0	1	3
27	2100	70	3	3	0	3	0	2.75
28	2600	171	20	4	2	2	1	4

29	5500	37	2	3	0	0	0	1.2
30	1700	117	9	12	2	0	0	0
31	2500	156	2	1	2	0	1	1.5
32	2500	95	4	2	2	0	0	1
33	2820	160	5	1	0	0	0	0.5
34	1670	105	4	2	2	1	0	0.5
35	2110	103	5	4	0	0	0	0.5
36	1650	180	6	4	1	0	0	0.5
37	1660	220	4	3	1	0	0	0.5
38	3000	550	24	75	5	2	1	5
39	2462	94	6	45	1	0	0	4
40	2300	600	21	65	4	3	0	5
41	4000	400	22	54	4	2	0	6
42	3000	650	10	60	3	1	0	5
43	2600	512	13	55	5	4	2	5
44	2485	265	15	5	1	2	1	2.9
45	3000	265	10	50	4	2	0	5
46	1512	215	12	4	0	0	0	2.2
47	1413	115	8	4	1	3	0	2.6
48	3	215	225	10	2	4	10	2
49	1645	242	15	7	2	5	0	2.3
50	2935	238	12	6	3	2	0	2.6
51	2085	158	10	5	6	4	0	2.7
52	2000	260	8	12	3	7	1	4
53	2110	212	16	6	1	5	0	4
54	2650	200	5	4	0	10	0	4
55	3500	165	6	6	0	2	0	3
56	2650	168	8	4	0	0	1	1.1
57	2000	80	4	8	1	1	0	1
58	4500	171	7	1	0	2	0	1.2

59	350	91	7	4	1	3	0	0.7
59	1349	685	42	24	6	10	0	3
60	1385	547	32	14	7	12	0	4.5
61	2350	150	9	5	1	1	1	2
62	2951	190	12	147	4	4	1	4
63	2853	505	26	60	10	9	1	4.5
64	1763	2126	37	7	0	9	0	5.5
64	1100	820	34	300	3	6	0	3
65	1697	1943	36	5	1	7	1	16.5
65	800	452	22	155	1	3	0	1.8
66	2256	328	18	2	1	0	0	4
67	2836	190	11	4	1	0	0	4.5
68	3080	521	31	56	9	4	1	4.5
69	3370	150	6	1	1	0	0	0.6
70	3425	242	11	1	0	0	1	0.6
71	2700	83	5	2	1	4	0	1
Total	175189	20639	841	1484	131	255	31	140.5

Source: Cochin Corporation

Feature

Conceptualizing Energy Efficiency: A Techno-Economic Approach

VIJAYAMOHANAN PILLAI N. AND A. M. NARAYANAN

Conserving electrical energy through energy efficiency measures can meet the dual challenges of increasing energy demands at reasonable costs in a sustainable manner, and of reducing the environmental and health threats associated with the use of hydrocarbons, having the potential to encourage clean energy systems. The present paper seeks to document the techno-economic conceptualization of energy efficiency as a prelude to a documentation of the analytical methods of its measurement, which we consider in another paper. Defining energy efficiency in the Patterson's sense of useful output per unit of input leads us to define energy efficiency also as an increase in net benefits per unit of energy. This helps us differentiate between energy efficiency and energy conservation, which is an important complement to the former. It is possible to design and devise energy efficiency indicators at different levels of aggregation in a pyramidal structure, using the corresponding statistics, such as the international statistics for national level indicators, national economic statistics for various macro-sectoral indicators and so on down to the most disaggregated micro level data on individual plant for the corresponding operational units. It is generally believed that energy consumption at any level of aggregation is essentially determined by three effects, viz., activity, structure and intensity. The paper presents a detailed illustration of this for the bottom micro-level sectors, as well as a conceptual framework that can be followed in an empirical exercise.

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1. Introduction

One positive impact of the 1973 oil crisis has been the concerted effort across the world to reduce energy consumption through energy efficiency improvements. Improving energy efficiency ensures the objective of conserving energy and thus promoting sustainable development. Recognition of this fact has now appeared in terms of including the aim of improving efficiency as an important component of electrical energy policy in all the countries across the globe. Conserving electrical energy through energy efficiency measures can meet the high challenge of increasing energy demands at reasonable costs in a sustainable manner. Moreover, improving energy efficiency also has the potential of reducing the environmental and health threats associated with the use of hydrocarbons, and of encouraging clean energy systems.

Energy conservation is usually defined as a deliberate reduction in using energy below a certain level of current state of affairs (Munasinghe and Schramm, 1983). This may be achieved at both the ends of supply and demand, and works through load management of electricity usage, including direct (mechanical) controls on end-use equipments and power cuts on supply side and time-differential tariffs and other management measures on the demand side. "Load management meets the dual objectives i) of reducing growth in peak load, thus nipping the need for capacity expansion, and ii) of shifting a portion of the load from the peak to the base-load plants, thereby securing some savings in peaking fuels. By moving toward achieving these objectives, electric utilities stand to win a cut in operating and capacity costs, share the gain with the consumers and provide a partial solution to the country's energy dilemma." (Pillai 1992).

Improving energy efficiency is expected to reduce energy demand through its rational use in the end-use devices; every unit of energy input consumed will bring in greater amount of useful energy output. The energy efficiency of most of the end-use appliances that we use is pretty low, with consequent losses and higher demand for inputs, leading to environmental damages. This, in turn, suggests that improving energy efficiency can manage energy demand in better ways and contribute highly to a better environment. It is estimated that higher energy efficiency standards for residential and commercial appliances in the US could result in a cumulative total energy savings of nearly 26 quads for the period 2010–2030 (1 quad ≈ 293,071,000,000 kilowatt-hours) (Rosenquist *et al.,* 2004).

The International Energy Agency (IEA, 2018) estimates that the primary energy demand has grown by 39 per cent since 2000, whereas the global economy, by nearly 85 per cent. "The forces driving energy demand, led by strong economic growth, outpaced progress on energy efficiency. As a result, energy intensity–primary energy use per unit of gross domestic product (GDP)–fell by just 1.7 per cent in 2017, the slowest rate of improvement since 2010" (IEA, 2018: 17). IEA points out that in fact the higher economic activity would have led to a much higher energy demand, without energy efficiency progress. "Efficiency improvements made since 2000 prevented 12 per cent additional energy use in 2017" (ibid).

Energy efficiency has become essential to the environment and economic growth. The global energy-related carbon dioxide (CO_2) emissions rose by 1.6 per cent in 2017, with a grim prospect of continued growth, far from the climate goals (International Energy Agency, 2018). Energy efficiency is accepted as the cheapest way to reduce global emission of greenhouse gases (such as carbon dioxide, methane, nitrous oxide and sulphur hexafluoride) (Enkvist, Nauclér, and Rosander, 2007). They have developed a cost curves approach to measure abatement cost of avoided greenhouse gases emissions (by subtracting potential cost savings (for example, from reduced energy consumption) from the annual additional operating cost (with depreciation) and dividing it by the amount of avoided emissions; note that this formula implies negative costs if there are considerable cost savings). "The abatement cost for wind power, for example, should be understood as the additional cost of producing electricity with this zero-emission technology instead of the cheaper fossil fuel-based power production it would replace. The abatement potential of wind power is our estimate of the feasible volume of emissions it could eliminate at a cost of 40 euros a ton or less." (ibid.)

It is estimated that efficiency gains made since 2000 have "prevented 12 per cent more greenhouse gas emissions and 20 per cent more fossil fuel imports, including over USD 30 billion (United States dollars) in avoided oil imports in IEA countries" (IEA, 2018: 17).

A comprehensive documentation of a techno-economic conceptualization of energy productivity and its analytical methods of measurement, is an essential prerequisite for a study on energy efficiency. The former, the techno-economic conceptualization, is important because it constitutes the basis on which the entire study is erected; it delineates significantly the approach to defining the concept under study and the definition itself in its subtle structure, which in turn determines the way towards discovering and deconstructing the measurement methods. The present paper is an attempt at the first of the tasks, the documentation of the techno-economic conceptualization of energy productivity, which we complete in the following seven sections. The next part of the paper discusses the energy efficiency indicators in terms of its conceptual definition. Part three differentiates in this light between energy efficiency and energy conservation. Following this background, a brief discussion of the laws of conservation of mass and thermodynamics is given in part four and the next section turns light onto energy efficiency indicators at different aggregation levels. Section six deals with the determinants of energy efficiency indicators and is followed by a conceptual framework for energy efficiency in Kerala, given in part seven. The final section concludes the study.

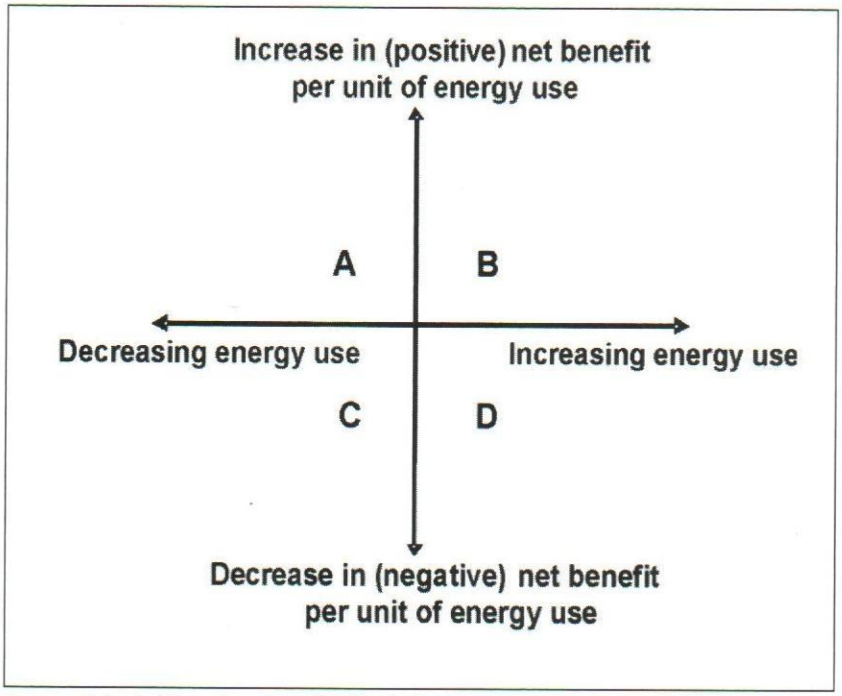
2. Energy Efficiency Indicators

Traditionally, there are two basically reciprocal Energy Efficiency Indicators: one, in terms of energy intensity, that is, energy use per unit of activity output, and the other, in terms of energy productivity, that is, activity output per unit of energy use. As a general concept, "energy efficiency refers to using less energy to produce the same amount of services or useful output. For example, in the industrial sector, energy efficiency can be measured by the amount of energy required to produce a tonne of product." (Patterson, 1996: 377). Thus, Patterson defines energy efficiency broadly by the simple ratio of the useful output of a process in terms of any good produced that is enumerated in market process, to energy input into that process (ibid.).

Defining energy efficiency in this sense (of useful output per unit of input) also helps us to define energy efficiency as "a change to energy use that results in an increase in net benefits per unit of energy" (section 3 of the Energy Efficiency and Conservation Act 2000 of New Zealand), where net benefits represent useful output.

3. Differentiating between Energy Efficiency and Energy Conservation

The concept of energy efficiency, thus defined, also clarifies the differences among the concepts of energy efficiency, energy conservation and energy saving. These differences may be better explained using Figure 1. The quadrants A and B represent energy efficiency, defined in terms of net benefits per unit of input. They also capture the idea of energy efficiency improvement, "defined [by Energy Efficiency and Conservation Authority, 1997?] as any change in energy use that results in increased net benefits per unit of energy, whether or not total energy use increases or decreases" (Lermit and Jollands, 2001, p. 7). Thus, quadrant B represents energy efficiency improvement, by increasing net benefits per unit of energy use through increasing energy use and quadrant A, on the other hand, represents energy efficiency improvement, by increasing net benefits per unit of energy use through decreasing energy use (for example, by installing double-glazing windows that can reduce heating energy bill costs during winter).



Source: Adapted from Lermit and Jollands (2001, p. 7).

Figure 1: The energy efficiency and conservation quadrants

Cases like quadrant B simply show that energy efficiency improvement need not imply energy savings and render monitoring energy efficiency difficult. "If energy efficiency were the same as energy savings, then all that would be required would be to estimate the amount of energy saved compared to some base year and add up energy savings across sectors. However, this does not necessarily equate to energy efficiency." (Lermit and Jollands, 2001, p. 8).

As already explained, energy conservation, as an important complement to energy efficiency, is defined in terms of reduction in total energy use, and is thus represented by quadrants A and C. Thus, this can happen in two ways: quadrant A represents efficiency-improving energy conservation, where energy savings lead to an increase in net benefits per unit of energy use; and quadrant C represents efficiency-reducing energy conservation, where energy savings lead to a decrease in net benefits per unit of energy use, "as is the case with the proverbial 'cold bath in the dark'" (ibid.).

In short, the above discussion reminds us that energy efficiency is a context-specific concept, not necessarily equivalent to energy savings, and is usually defined as net benefits (useful output) per unit of energy input, but without an unequivocal operationally useful quantitative measure. This necessitates construction of a series of indicators specific to the context (or level of sectoral disaggregation, as discussed below).

4. The Laws of Conservation of Mass and Thermodynamics

It goes without saying that an economic system is bound to operate within the immutable constraints set by the law of conservation of mass and the laws of thermodynamics (Boulding 1966; Ayres and Kneese 1969; Daly and Umana 1981). The conservation law states that mass cannot be created or destroyed and hence the total mass of all materials entering any process (input) must equal the total mass of all materials leaving (output), plus the mass of any materials accumulating or left in the process. That is, input = output + accumulation. When there is no accumulation of materials in a process, "what goes in just comes out", and such a process is called a *steady-state process.* This mass-balance principle (Ayres and Kneese, 1969) thus implies that, for a given material output, equal or greater quantities of material must be used as inputs, leaving a residual in terms of a pollutant or waste product, if any. This in turn means that any production process, involving material input-output relationships, is subject to some minimal material input requirements.

The first law of thermodynamics is a specialized version of the law of conservation of energy, reformulated for thermodynamic systems. It states that energy cannot be created or destroyed: it can only be transformed from one form of energy to another. Thus, work (which is a form of energy) can be transformed completely into heat. The second law of thermodynamics, on the other hand, relates to the reverse transformation of heat into work, and states that it is not possible to completely transform heat into work; this means that no energy-conversion process is 100 per cent efficient. Thus, this law in its simplest form becomes useful in assessing the thermal efficiency of heat engines, and in a more general form introduces the concept of the 'quality' of energy.

As all activities involve work and thus energy, so do all economic activities; all economic production processes must require a minimum quantity of energy this in turn implies that there is a limit to the substitution of other factors of production for energy, and this makes energy always an essential factor of production (Stern, 1997).

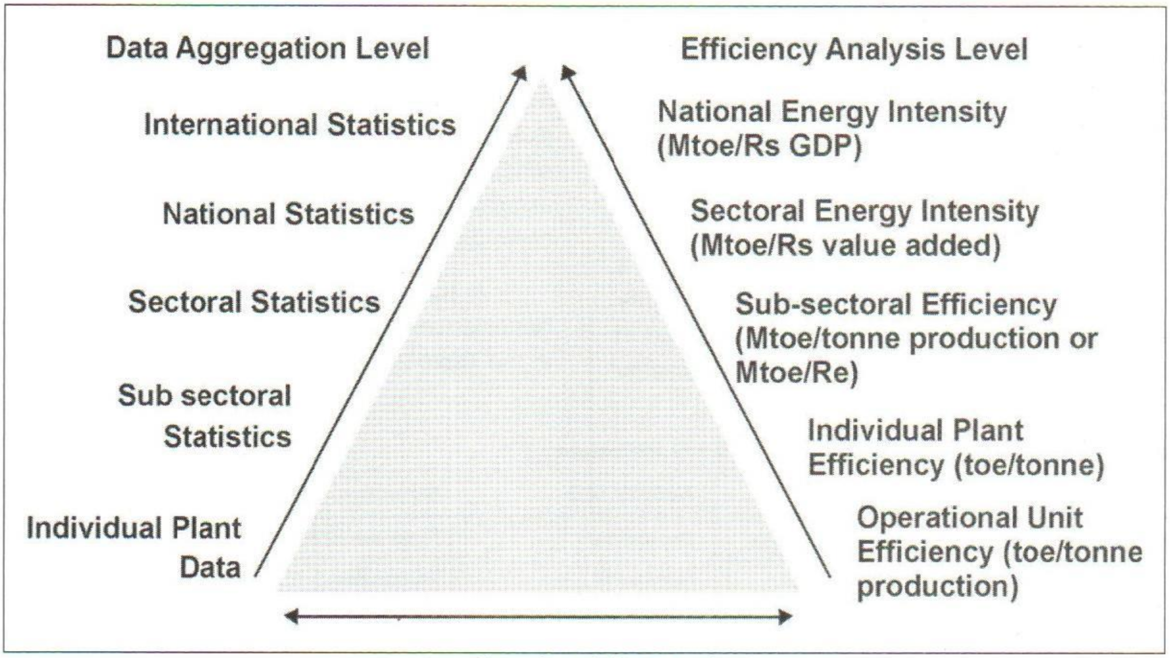
As we know, the production function helps in defining marginal products of inputs and in distinguishing between allocative efficiency and technical efficiency. In addition to the marginal productivities, we can also have average productivities of the inputs, the partial factor productivity, in terms of the output divided by the input. Thus, taking energy as one of the inputs in a production function yields marginal and partial (average) energy productivity, the inverse of the latter being energy intensity.

One of the first detailed empirical analyses of consumption of fuels and water power in the "United States" economy was by F. G. Tryon in 1927, who stated that "Anything as important in industrial life as power deserves more attention than it has yet received from economists .... A theory of production that will really explain how wealth is produced must analyze the contribution of this element energy." (Tryon, 1927: 271).

However, the significance of energy in economic growth started to attract the researchers' curiosity only by the start of the 1950s. In October 1950, Harold J. Barnett came out with an Information Circular for the U.S. Bureau of Mines, entitled Energy Uses and Supplies, 1939, 1947, 1965. In it, he documented for the first time that the consumption of energy relative to GNP (i.e., energy intensity) had been declining persistently over a long period of time following World War I. This led to an interest among the researchers to analyze the role of energy in economic growth, and the prime importance of energy in economic productivity growth was first established in a classic study Energy and the American Economy, 1850–1975 by Sam H. Schurr and Bruce C. Netschert (along with their associates Vera F. Eliasberg, Joseph Lerner and Hans H. Landsberg) in 1960. They noted that both energy intensity and labour intensity of production had fallen from 1920 to 1955, and the total factor productivity had risen. The simultaneous decline of both energy and labour intensity of production left the factor substitution possibility a puzzle and pointed towards technical change as a possible critical explanatory factor. Schurr and his associates found that the electricity consumption had increased by a factor of more than ten during the period from 1920 to 1955, while utilization of all other forms of energy only doubled. It was also noticed that the thermal efficiency of conversion of fuels into electricity during this period increased by a factor of three, and the electrification of industrial processes had led to much greater flexibility in the application of energy to industrial production. Significant fall in energy intensity was found in many developed and developing countries in the recent decades also (Gales *et al.,* 2007, Stern, 2010).

5. Energy Efficiency Indicators at Different Aggregation Levels

It is possible to design and devise energy efficiency indicators at different levels of aggregation, using the corresponding statistics. Thus at the highest level of aggregation, we can use the international statistics for national level indicators, and from there we can come down to different disaggregated levels of a national economy; for instance, using national economic statistics, we can have various macro-sectoral indicators, and coming down to the most disaggregated micro level data on individual plant, we can construct energy efficiency indicators of the corresponding operational units. This is illustrated in Figure 2, in a pyramid framework.



Quantity of data required

Figure 2: Energy Efficiency Indicator Pyramid

Note: Mtoe = Million Tonnes of Oil Equivalent; the tonne of oil equivalent (toe) = a unit of energy = the amount of energy released by burning one tonne of crude oil; approximately 42 gigajoules or 11,630 kilowatt hours.

As we know, higher levels of aggregation conceal many relationships and effects, functioning at the micro levels. As we move down the pyramid to micro levels, these relationships and effects appear more clearly, providing better understanding of the ground reality that throws more light on the macro-level reality. However, the quantity and quality of data required at the bottom of the pyramid increases substantially, and the data availability becomes more and more difficult.

6. Determinants of Energy Efficiency Indicators

It is generally believed (for example, Schipper, *et al.,* 1992; Phylipsen *et al.,* 1998) that energy consumption is essentially determined by the following effects:

(i) Activity (Ai) – economic or human activity level (output/income produced, population/households supported, passenger-km travelled, etc).

(ii) Structure (Si) – the composition of activity (shares of different sectors or subsectors of human/economic activities).

(iii) Energy intensity (Ii =Ei/Ai) – quantum of energy required to deliver one unit of economic/human activity.

Thus, the total energy consumption across all the sectors

$$E = \sum_i E_i = \sum_i A \frac{A_i}{A} \frac{E_i}{A_i} = \sum_i A S_i I_i$$

where E is the total energy consumption, A $(= \Sigma_i A_i)$ is the activity level, S_i $(= S_i/S)$ is the ith sector's activity share and I_i $(= E_i/A_i)$ is that sector's energy intensity.

Recent contributions have included two additional parameters, viz, climate and behaviour. However, in practice, we can find that they are only part of the basic factors given above, as climate is a structural factor, for example, for heating applications, and behaviour is a part of energy intensity.

The level of aggregation, as outlined above in the pyramid structure, determines the exact definitions and units of these factors. Thus at the highest aggregation level of the macro economy, the activity is measured in economic terms (GDP or value-added, VA), and hence energy intensity, in terms of energy consumption, Giga Joule per unit of GDP (GJ/GDP) or per unit of value-added (GJ/VA); similarly, structure is defined as the share of the different sectors (primary, secondary and tertiary). At a lower level of aggregation, for instance, the steel industry within the industry sector, activity may be measured in either value-added or tonnes of steel produced, energy intensity in either GJ/VA or GJ/tonne steel, and structure in terms of the share of primary and secondary steel in total or in some other shares.

A detailed illustration of this for the bottom micro-level sectors is given in Table 1 that follows. For example, the residential or domestic sector consists of several subsectors such as space heating/cooling, water heating, cooking, lighting, appliances, etc. Activity in each subsector is measured in terms of the corresponding population or number of households, structure in the case of space heating/cooling and lighting is defined in terms of floor area per capita and intensity in terms of energy per square feet floor area. In transport sector, passenger and freight transport are the two subsectors, with passenger-km and ton-km as respective activities. The other two factors are similarly defined. Both in services and manufacturing, value-added measures the activity with corresponding shares and intensity factors.

A number of different formulations are used to generate energy efficiency indicators such as those given in the Table 2.

Table 1: Micro-level Determinants of Energy Efficiency Indicators

Sector (i)	Subsector (j)	Activity (Aj)	Structure (Sj)	Intensity (Ij = Ej/Aj)
Residential or domestic	Space heating/cooling	Population, Number of Households and Floor area (sq. ft.)	Floor area/capita	Energy/floor area
	Water heating		Person/HH	Energy/capita
	Cooking		Person/HH	Energy/capita
	Lighting		Floor area/capita	Energy/floor area
	Appliances		Ownership/capita	Energy/appliance
Transport	**Passenger** Car Bus Rail Domestic air	Passenger-km	Share in total Passenger-km	Energyper passenger-km
	Freight	Ton-km	Share in total Ton-km	Energy per Ton-km
	Trucking Pipelines (Natural gas Petroleum) Air Water			
Services	Any sector	Value-added	Share in total VA	Energy/VA
Manufacturing	Any sector	Value-added	Share in total VA	Energy/VA

Source: Adapted from Schipper, *et al.*, 2001; and https://www.energy.gov/sites/prod/files/2015/06/f24/index_methodology.pdf

Table 2: Determinants of Energy Efficiency Indicators

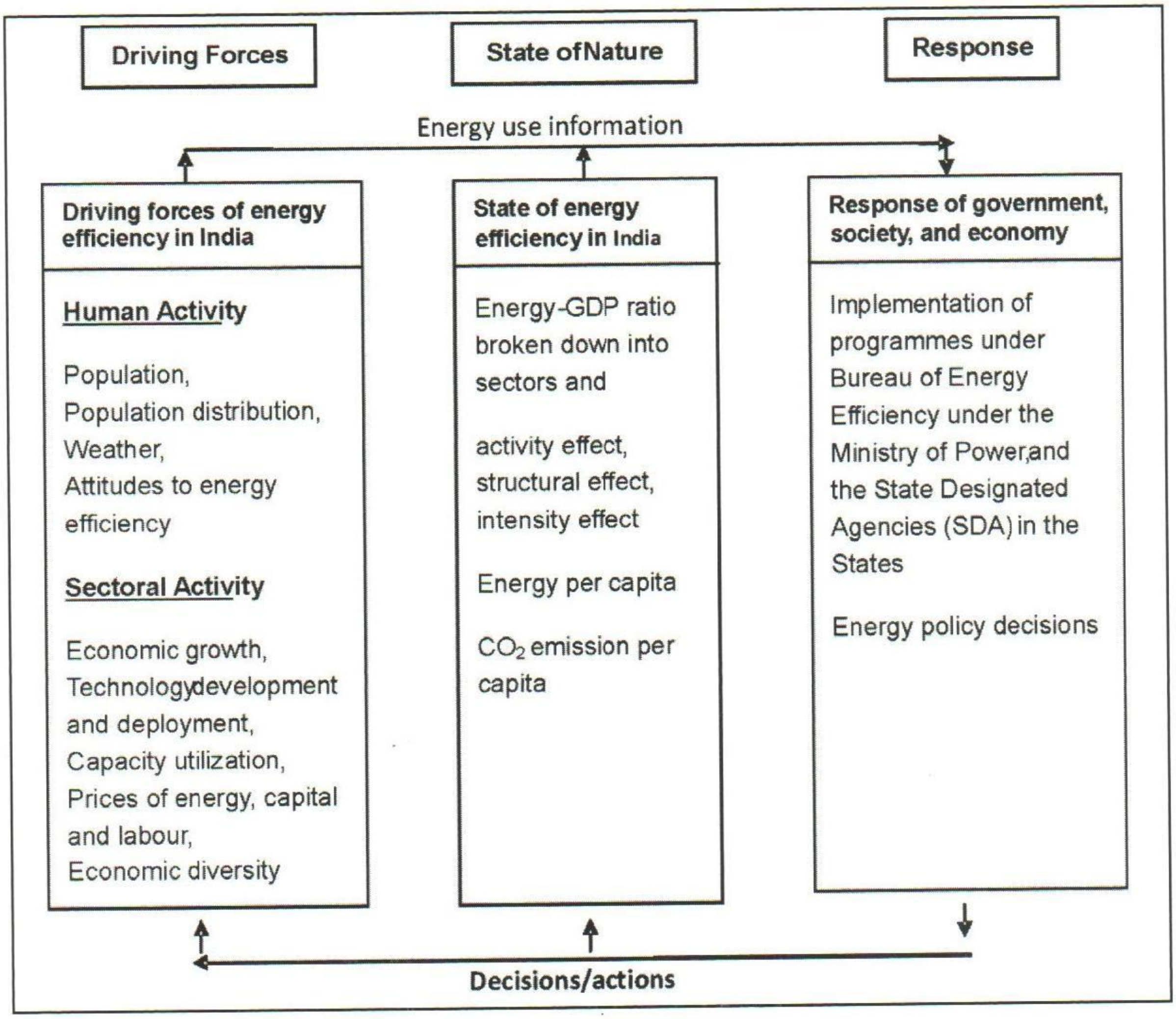
Aggregation level	Indicator	Combines effects of	The indicator can assess	The indicator cannot assess
Economy as a whole	Energy per GDP	Share of different sectors and subsectors,energy intensity of each of the (sub-) sectors,costs of the production factors (energy, material, labour) andvalue of products and services delivered,share of sectors that do not generate (account for) value	Energy required to produce an amount of GDP	Energy efficiency,level of development,future trends,improvement potentials
Sectoral intensity				
Industry	Energy per VA	Share of different types of subsectors,energy intensity of each of the sub-sectors,costs of the production factors (energy, material, labor) and value of products delivered	Final energy required to produce an amount of VA in this sector	Share of primary resources to generate VA; Future trend in energy consumption;Energy efficiency;Improvement potential
Residential	Energy per capita	Dwelling size (square feet/house),household size (number of people/house),type of dwellings,number of appliances,usage of appliances (number of hours),climate,efficiency of dwelling and appliances,behaviour		Energy required for a certain level of welfare or services provided;Energy efficiency;Energy efficiency improvement potential
Transport	Energyper passenger-km or per ton-km	Share of passenger transport and freight transport,share of various modes (car, bus, truck, train, boat, plane),occupancy load (number of passengers or ton per vehicle), distance travelled by each of the modes, energy intensity of each of the modes		

Source: Adapted from G.J.M. Phylipsen, Energy Efficiency Indicators: Best practice and potential use in developing country policy making. 30 June 2010 Phylipsen Climate Change Consulting, Commissioned by the World Bank. P. 19.

7. A Conceptual Framework for Energy Efficiency in India

A conceptual framework for monitoring energy efficiency of India may be summarized as follows (see Fig. 3):

The illustration is self-explanatory, and hence we do not venture for a tautology. However, it is essential to note that an empirical exercise can have this framework: we can consider both the human and the sectoral activity as the driving forces of energy efficiency in India, and accept the state of nature of energy efficiency in terms of energy-GDP ratio, broken down into different sectors and effects, such as activity effect, structural effect, and intensity effect.



Source: Adapted from Lermit and Jollands (2001, p. 17).

Figure 3: Framework for Energy Efficiency

8. Conclusion

The present paper has attempted at a comprehensive documentation of the techno-economic conceptualization of energy productivity as a prelude to a comprehensive documentation of the analytical methods of its measurement.

We have, in this paper, started with a discussion of the energy efficiency indicators in terms of its conceptual definition. Defining energy efficiency in the Patterson's sense of useful output per unit of input leads us to define energy efficiency also as an increase in net benefits per unit of energy. This helps us differentiate between energy efficiency and energy conservation, which is an important complement to the former. Energy conservation is defined in terms of reduction in total energy use, which can happen in two ways: one representing efficiency-improving energy conservation, where energy savings go along with an increase in net benefits per unit of energy use; and the other representing efficiency-reducing energy conservation, where energy savings results in a decrease in net benefits per unit of energy use.

Following this background is a brief discussion of the laws of conservation of mass and thermodynamics and of some of the important earlier studies on energy-economic growth relationship. Then we have turned the light onto energy efficiency indicators at different aggregation levels, presented in a pyramidal structure, and onto the determinants of energy efficiency indicators. It is generally believed energy consumption is essentially determined by three effects, viz., activity, structure, and intensity. A detailed illustration of this for the bottom micro-level sectors also is provided thereafter. For example, the residential or domestic sector consists of a number of subsectors such as space heating/cooling, water heating, cooking, lighting, appliances, etc. Activity in each subsector is measured in terms of the corresponding population or number of households; structure in the case of space heating/cooling and lighting is defined in terms of floor area per capita and intensity in terms of energy per square feet floor area. The paper concludes with a conceptual framework that can be followed in an empirical exercise.

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The conservation of natural resources is the fundamental problem. Unless we solve that problem it will avail us little to solve all others.

– Theodore Roosevelt

Feature

Digital Platform Economy: Overview, Emerging Trends and Policy Perspectives

S.K. SASIKUMAR AND KANIKKA SERSIA

The COVID-19 crisis has stimulated an unprecedented surge in digitalisation, which has in turn massively accelerated the growth of the digital platform economy. The increasing significance of digital platforms is apparent as millions of people turn towards them for work, livelihood, trade, information and entertainment. This paper is an attempt to situate the growth and diversification of digital platforms in the post-pandemic economic scenario. The paper delineates the theoretical underpinnings of digital platforms with a focus on definition, characteristics and typology. It highlights the emerging trends in the overall digital economy and traces the potential future contours of digital platforms. The paper also discusses key labour market issues with respect to the digital platform economy as well as some major policy imperatives to situate platform work within the frame of a brighter future of work.

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Introduction

While the COVID-19 pandemic has caused considerable hardship, it has ushered in an unprecedented digital transformation that has permanently fused technology with our everyday lives and work environment. This has accelerated the already fast pace of growth and diversification of the digital platforms. Several companies in the platform economy have massively scaled up their operations as a response to the pandemic. GAFAM (Google-Alphabet, Apple, Facebook, Amazon and Microsoft), which forms the infrastructural edifice of the platform ecosystem, clocked huge profits in the first six months of 2020 as opposed to airlines, hotel chains, restaurants and millions of small businesses that are fighting for survival amid the COVID-19 pandemic (Figure 1). In fact, Amazon doubled its profit in the second quarter of 2020 as more people ordered delivery to their homes: $5.2 billion in 2020 from $2.6 billion in 2019 (Lopatto, 2020). The estimated 50 million gig workers around the world proved to be key workers during the crisis (Fairwork Foundation, 2020). The platform workers are involved in services such as delivery of food and household essentials to the self-isolating masses. This has been made possible only because of the ready availability of an on-demand, at-risk flexible workforce. The pandemic has also been accompanied by a crowd work revolution. Online crowd work-based education tutoring systems have augmented a path towards delivering more scalable education at large. In a post-pandemic world, it can be envisaged that many jobs that once required physical presence in an office are done remotely, in a virtual workspace.

The growing importance of the platform economy is apparent with millions of people turning towards digital platforms for work, livelihood, information entertainment. Even as companies outsource their work, the workforce

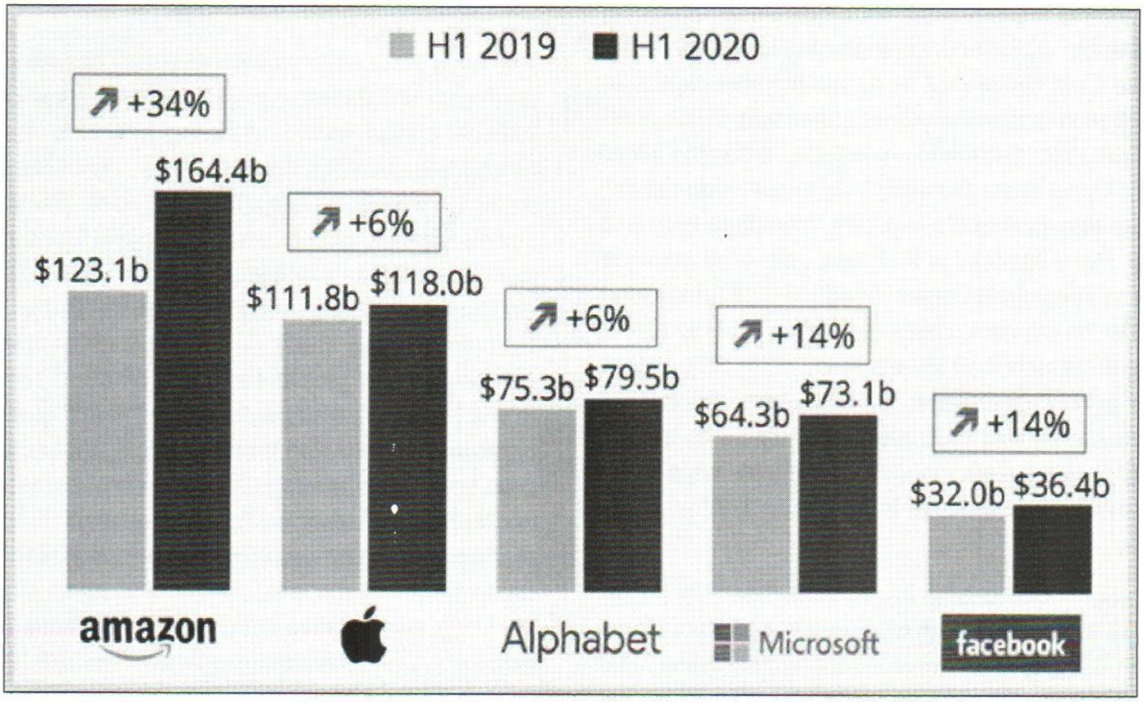


Figure 1: Revenue of Big Five Tech Companies in the First Six Months of 2020 vs. 2019.

increasingly favours the flexibility of work possible in the platforms. Investors value platforms more than any other businesses today. So much so that sovereign governments across the world are struggling to develop a consensus solution to the tax challenges arising from the digitalisation of the economy (OECD, 2019). While much of the traditional work designs are focused on work practice, with digital platforms, technology is now directly involved in labour issues.

Digital platforms have influenced social relations and scope for interaction such that platforms like Uber, MTurk, Zomato, etc. not only manage the allocation of work but also deal with the labour conditions at work. For instance, in the case of Uber, the app manages not just the allocation of rides, but is also engaged in processing payments, tracking distance, calculating fares mediating the relationship between the company and its drivers (Glöss *et al.,* 2016). One of the strongest critiques of platform businesses comes from the advocates of labour rights who argue that using terms like 'independent contractors', 'micro-entrepreneurs', or 'self-employed' for platform workers is a deliberate strategy to deprive labour of their employment-related entitlements and benefits. A new working class is emerging—the precariat—characterised by uncertainty and insecurity (Standing, 2011). The platform labour that faces rising informalisation and lack of quality jobs, autonomy, unionisation rights social security net, have been exposed to maximum vulnerability during the COVID-19 crisis.

However, there is a silver lining. Several acclaimed studies and reports indicate that digital platforms, which currently account for a relatively lower proportion of employment in most developing and developed economies, are expected to generate considerable job opportunities in the coming years (ILO, 2020; Chaudhary, 2020; Chakraborty, 2020). More importantly, the majority of those engaged in the technology-driven new forms of employment are young workers, including a large proportion of women. This has huge implications for a country like India, where one in every five young person (15–29 years) in the world currently lives, and also where the labour force participation of women is comparatively low. In fact, India already accounts for 21.5 per cent of workers signed up to online outsourcing sites worldwide, second only to the United States (MGI, 2019). Digitalization has also empowered women in India by helping them find gainful employment. For example, 54,800 women have become village-level entrepreneurs at government-run Common Service Centres (CSCs), providing digital services to the local population (ibid.). The digital platform economy has also opened new opportunities for women. For instance, out of the total 20,000 service professionals in Urban Company, women comprise 8,000 (40 per cent), and are mostly concentrated in the beauty, spa fitness segment (Chaudhary, 2020).

Additionally, industry analysts suggest that facilitating the spread of the digital economy across different sectors and activities will be pivotal in hastening the pickup in economic growth and employment generation in the post-pandemic scenario. Growth is expected in a diverse set of sectors, ranging from financial services, education, healthcare to transport, trade, logistics, manufacturing, and agriculture. For instance, in logistics, real-time tracking of vehicles has enabled truckers to reduce fleet turnaround time by 50 to 70 per cent, digitising supply chains allows companies to reduce their inventory by 10 to 20 per cent and in the agricultural sector, digitalisation can enable farmers to cut the cost of growing rice by 15 to 20 per cent by harnessing data on soil conditions, which can help them minimise the use of fertilisers and other inputs (MGI, 2019).

It is within this broad framework that this paper attempts to situate the growth and diversification of digital platforms in the post-pandemic economic scenario. The paper outlines the theoretical underpinnings of digital platforms with a focus on definition, characteristics and typology. It highlights the emerging trends in the overall digital economy and the potential future trajectory of digital platforms. The paper also discusses key labour market issues with respect to the digital platform economy, and delineates major policy imperatives to locate platform work in the context of a brighter future of work.

2. Overview of Digital Platforms

As the Fourth Industrial Revolution took off, rapid digitalisation started to profoundly change the size, types and task content of the available jobs and work organisations of the traditional labour market. The leap forward from the industrial factory floor set-up to the digital application-based economy also challenged the existing labour practices and employment relationships. The discourse around digital platforms is full of buzzwords such as sharing economy, collaborative economy, gig economy, freelance economy, peer economy, access economy, crowd economy, digital economy, etc. Unfortunately, this discourse often suffers from inconsistencies in the use of terminology, and confusion in the categorisation of different platform types. It is therefore important to be cautious, as a broader approach would run the risk of overestimating the impact of these new business models while not being able to differentiate them from traditional models, and a narrower approach would simply limit the scope of our understanding.

2.1 Defining Digital Platforms

The term platform is used in a variety of ways. For many, platforms are technological tools that allow users to do various things online: chatting, sharing, commenting, searching, buying commodities, listening to music, watching videos, hailing a cab, and so on. But these online activities hide a system whose logic and logistics are about more than facilitating; they actually shape the way we live and how the society is organised (Gehl, 2011). Evans and Gawer's (2016) study sought to provide the first-ever comprehensive global survey of platform companies. It notes that most of today's platforms are digital, as they capture, transmit and monetise data, including personal data, and take advantage of the power of pervasive internet connectivity. (Parker *et al.,* 2016) put forth the view that a platform enables 'value-creating interactions between external producers and consumers' even as it provides 'an open, participative infrastructure for these interactions and sets governance conditions'. Tiwana (2014) goes a step further to explain the platform ecosystem as 'the collection of the platforms and the apps specific to it' where platforms are the 'extensible codebase of a software-based system that provides core functionality shared by apps that interoperate with it, and the interfaces through which they interoperate'. After studying different sets of definitions, OECD (2019) modified and curated a definition for platforms which not only focuses on platforms that operate online but also expresses more accurately what online platforms can do. It asserts that an online platform is a digital service that facilitates interactions between two or more distinct but interdependent sets of users (whether firms or individuals) who interact through the service via the internet (OECD, 2019).

Defining digital platforms in the light of the contemporary capitalist economy, Srnicek (2016) argues that platform capitalists rely heavily upon information technology, data and the internet for their business models. Srnicek defines platforms as digital infrastructures that enable two or more different users to interact together: customers, advertisers, service providers, producers, suppliers and even physical objects. However, Van Dijck (2013) points out that 'a platform is a mediator rather than an intermediary', because it shapes the performance of social acts instead of merely facilitating them. (Van Dijck *et al.,* 2018) later introduced the concept of the platform society, an even more encompassing term than platform ecosystem, to describe a situation where almost everything in society has undergone a process of platformisation. They define a platform as 'programmable architecture designed to organise interactions between users' with the following elements going into the construction of its anatomy: 'a platform is fueled by data, automated and organized through algorithms and interfaces, formalized through ownership relations driven by business models, and governed through user agreements'.

As seen above, most definitions are limited to the idea that the platform is an interface between users, businesses and technology. In a more refined academic sense, Jin (2015) explores platforms within the realm of political ideology. The global flow of culture and technology has been inherently asymmetrical in nature, as suggested by the theories of cultural and media imperialism; similarly, platforms are characterised by unequal technological exchanges and skewed capital flows that have led to the technological domination of a few US based companies, sustaining unequal power relations with other countries. Jin critically analyses the political culture—including both intellectual property rights and the current debates on the global digital divide, together with the threat of ideological domination of western countries and tech developers—which feeds into the process of platform imperialism. Jin's ideological paradigm is in line with Marxist theorists Couldry and Mejias (2018) who characterise this entire process of the transformation of user data for monetisation purposes as data colonialism.

2.2 Characteristics of Digital Platforms

Given the short history of platforms, it is not surprising to find that there has been no confirmed definition. But there are widely agreed characteristics from the conceptual adaptations of the digital platforms (Table 1).

1. **Intermediary**: Platforms as intermediaries enable different user groups, such as workers, customers, advertisers, service providers, producers, suppliers and even physical objects, to interact with each other.
2. **Network Effects**: While the traditional industrial businesses gained dominance through supply-side economies of scale, platform business models rely on-demand economies of scale. Digital platforms rely and thrive on network effects, whereby, increased user participation in the platform in turn attracts more participation (Srnicek, 2016).
3. **Cross-subsidisation**: Without workers, consumers do not find value in using the platform, and without consumer participation, workers may not use the platform. To overcome this hurdle, the platforms tend to subsidise initial participation to increase its user-base (ILO, 2018b).
4. **Constant User-engagement**: Platforms deploy the strategy of constant user-engagement, with the end purpose of extracting (more) data from its users (Srnicek, 2016).
5. **Reduced Transaction Costs**: Digital platforms are designed to reduce transaction costs like search and information costs, bargaining costs, and policing and enforcement costs to encourage repeated transactions (ILO, 2018b).
6. **Reputation System**: Repeated transactions on the platforms standardise consumer experience. These get more or less formally translated into metrics, understood as 'reputational score' (Gandini, 2018). This is fundamental in the platform economy, as this reputational score is used by consumers/clients as forms of evaluation of workers and proxies for trustworthiness.
7. **Algorithmic Managerial Control**: Algorithmic management forms the basis of interaction in digital platforms (Wood *et al.,* 2019). Algorithmic control enables the capture, processing and control of every user-activity as data across the world on a real-time basis.

Table 1: Characteristics of Digital Platforms

Digital Platforms as Intermediary
Network Effects
Cross-subsidisation
Constant User-engagement
Reduced Transaction Costs
Reputation System
Algorithmic Managerial Control

2.3 Typology of Digital Platforms

Several attempts have been made to provide a typology for platforms (Table 2). From the perspective of business strategists, Evans (2016) categorises platform companies into four types: transaction platforms, innovation platforms, integrated platforms and investment platforms. (Van Dijck *et al.*, 2018) categorise platforms into two types: infrastructural and sectoral platforms. Infrastructural platforms form 'the heart of the ecosystem' upon which other platforms are built and are mostly 'owned and operated by the Big Five'. For example, Uber depends on Google for GPS navigation, and many other platforms frequently must rely on Facebook or Google for their login facilities. Sectoral platforms offer digital services for one particular sector, such as health, education, retail, transportation, etc. A much narrower approach is developed by Srnicek (2016) who categorises platforms into five different types where the important element is that the capitalist class owns the platform: advertising (e.g. Google), cloud (e.g. Amazon Web Services), industrial (e.g. Siemens), product (e.g. Spotify) and lean (e.g. MTurk). Srnicek's approach provides a clear understanding of platforms based on data extraction but disregards the labour dimension.

The International Labour Organization (ILO, 2018a) based on Schmidt (2017) distinguishes commercial digital labour platforms between 'web-based' and 'location-based'. It does not consider the prominence of the product but only the production process per se. While web-based platform work requires giving tasks either to the crowd (micro-tasking or contest-based creative tasks) or directly to individuals using a freelance marketplace, location-based work is where most of the tasks are given to individuals (with some given to the crowd), sub-categorised based on the type of work: accommodation (e.g. Airbnb), transportation (e.g. Uber, Ola), delivery (e.g. Zomato, Swiggy), household services (e.g. TaskRabbit), and local micro-tasking (e.g. Streetspotr).

On similar lines, Graham and Woodcock (2018) distinguish between three types of platform work based on the labour process. Type A consists of location-specific labour platforms which are geographically sticky, for instance Uber (with transport) and Swiggy (with food delivery). The next two types are digitally mediated in ways that are less location-specific but differentiated in terms of the skill involved. Type B comprises micro-task platforms that involve short tasks distributed via crowdsourcing and require relatively similar kinds of skills (MTurk or Crowdflower). Type C denotes freelance platforms involving more specific skills and facilitating a more direct relationship between client and worker (Upwork or Freelancer). Hence Type B and Type C are differentiated in terms of the scale from micro-task to macro-task. Further, on the basis of ownership of means of production, platforms are divided into capital platforms and labour platforms (JP Morgan Chase & Co. Institute, 2016). While capital platforms (e.g. Airbnb) connect customers with individuals who lease assets or sell goods peer-to-peer, labour platforms such as Uber or TaskRabbit connect customers (hirers) with freelance or contingent workers where participants perform discrete tasks.

Table 2: Typology of Digital Platforms

Peter C. Evans (2016)	Transaction Platforms; Innovation Platforms; Integrated Platforms; and Investment Platforms.
JP Morgan Chase (2016)	Capital (e.g Airbnb); and Labour (e.g TaskRabbit) Platforms.
Nick Srnicek (2016)	Advertising (e.g. Google); Cloud (e.g. AWS); Industrial (e.g. Siemens); Product (e.g. Spotify); and Lean Platforms (e.g. Ola).
Jose van Dijck *et al.*, (2018)	Infrastructural (Big Five); and Sectoral Platforms (Health, etc.).
ILO (2018a)	Web-based and Location-based Platforms.Location-based platforms are further sub-categorised based on the types of tasks: Accommodation (e.g. Airbnb), Transportation (e.g. Ola), Delivery (e.g. Zomato), Household Services (e.g. Task Rabbit), and Local Micro-tasking (e.g. Streetspotr).
Mark Graham and Jamie Woodcock (2018)	Type A: Location-specific (e.g. Swiggy); Type B: Micro-task (e.g. MTurk); and Type C: Macro-task (e.g. Upwork).

3. Digitalisation and Platformisation: Emerging Trends

With every digital innovation and its application, the digital economy is becoming increasingly inseparable from the functioning of the economy as a whole. As the world is still at the early stages of digitalisation, the evolving digital economy and several related economic terms lack widely accepted concepts and definitions. Hence, it becomes difficult not only to measure size but also to confine the scope of the digital economy.

For the purposes of this paper, we consider digital economy an all-encompassing term that includes three broad components (Figure 2). First, there is the *digital infrastructure* that forms the edifice of the process of digitalisation. This includes the core digital technologies ranging from basic computers to enabling infrastructures like the internet and telecommunication. Second is the *digital innovation* that is built over existing digital infrastructures. This includes the adoption of exponential technologies like automation and robotics, artificial intelligence (AI), Internet of Things (IoT), machine learning, data analytics, cloud computing, 3D printing and so on. Third and the last is *digital application*, which is the wider adoption of digital technologies that facilitate user interaction. This includes digital products and services being increasingly used in our everyday lives including digital platforms.

DIGITAL INFRASTRUCTURE	DIGITAL INNOVATION	DIGITAL APPLICATION
Computers, Processors, Supercomputers, Internet and Telecommunication Devices, Information and Communication Technologies (ICTs), etc.	**Automation and Robotics, Artificial Inteligence, Data Analytics, Internet of Things, Machine Learnin Cloud Computing, 3D Printing and so on.**	**Wider Adpoption of Digital Technologies that Facilitate User Interaction; includes Digital Products and Services like the Digital Plateforms**

Figure 2: Defining the Scope of the Digital Economy

The evolving digital economy is associated with the growth of digital infrastructures, innovation in exponential technologies, and adoption of digital applications. The estimates of the size of the global digital economy vary from 4.5 per cent of GDP to as much as 15.5 per cent of GDP based on the definition of digital economy (UNCTAD, 2019). In India, the core digital sectors (IT business process management, digital communication services and electronics manufacturing) have the potential to more than double their GDP level from $355 billion to $435 billion by 2025 (MGI, 2019). India is already among the top two countries globally on many key dimensions of digitalisation. Moreover, India, coming off a low base, is the second-fastest digital adopter among major digital economies with a narrowing digital divide (Figure 3).

Indian businesses are digitising rapidly but not evenly within the sector. According to McKinsey Global Institute's (MGI) India Firm Digitization Index, companies in the top quartile, considered to be digital leaders, had an average score of 58.2, while those in the bottom quartile, the digital laggards, averaged 33.2 on a scale of 0 to 100. Across the sectors, some have more digitally sophisticated companies than others. The top-quartile companies can be found in all sectors including those considered resistant to technology, such as transportation and construction (MGI, 2019). On the other hand, sectors such as information and communication technology, education and healthcare, which have more digitised firms on average, are represented in the bottom quartile. Such discrepancies within and across the sector suggest a lack of integrated sectoral strategy.

But India's digital economy is expected to contribute 18–23 per cent of overall economic activity by 2025, with more than half the potential coming from scaling up new and emerging digital ecosystems. MGI estimates that India has the potential to create considerable economic value by 2025: $130–170 billion in financial services (including digital payments); $50–65 billion in agriculture; $25–35 billion in retail and e-commerce (including supply chain); $25–30 billion in logistics and transportation; and roughly $10 billion in areas such as energy and healthcare (Figure 3). The value created by the digital economy of the future could support 60–65 million jobs by 2025 (MeitY, 2019). The key identified sectors show the biggest potential in job creation: 16–18 million in agriculture, followed by 10–12 million in manufacturing and construction, 10–12 million in trade and hotels, 7–8 million in IT-PM, finance, media and telecom, and 5–6 million in transport and logistics (MGI, 2019). If correctly harnessed, millions of digital professionals and workers in the service sector, micro, small and medium enterprises (MSMEs) and the farm sector can gain access to technology-enabled business models leading to improved skill matching and better income-earning opportunities. These trends have a corresponding impact on the overall growth of the digital platform ecosystem.

India No. 1 Globally	**1.2b** people enrolled in the world's largest unique digital identity programme				
India No. 2 Globally, behind China	12.3b App Downloads in 2018	1.17b Wireless Phone Subscribers	560b Internet Subscribers	354m Smartphone Devices	294m Social Media Users
Digital Adoption Index	**32** out of 100, India's score is low in absolute terms among major digital economies.		But India's score rose by **90%** between 2014 and 2017 in digital adoption. It is digitising the fastest, second only to Indonesia.		
Present Estimates	**7%** of India's GDP in 2017-18 Accounts for Core Digital Sectors ($170b)	**95%** Decline in Data Costs Since 2013	**152%** Annual Growth in Monthly Mobile Data Consumption Per User	**40%** Population has Internet Subscriptions	**94%** of Small Businesses Accept Debit or Credit Card pPayments
Least Value Creation by 2025 in Key Sectors	**$130b** Financial Services	**$50b** Agriculture	**$25b** Retail and E-commerce	**$25b** Logistics and Transportation	**$10b** Energy and Healthcare

Source: McKinsey Global Institute, 2019.

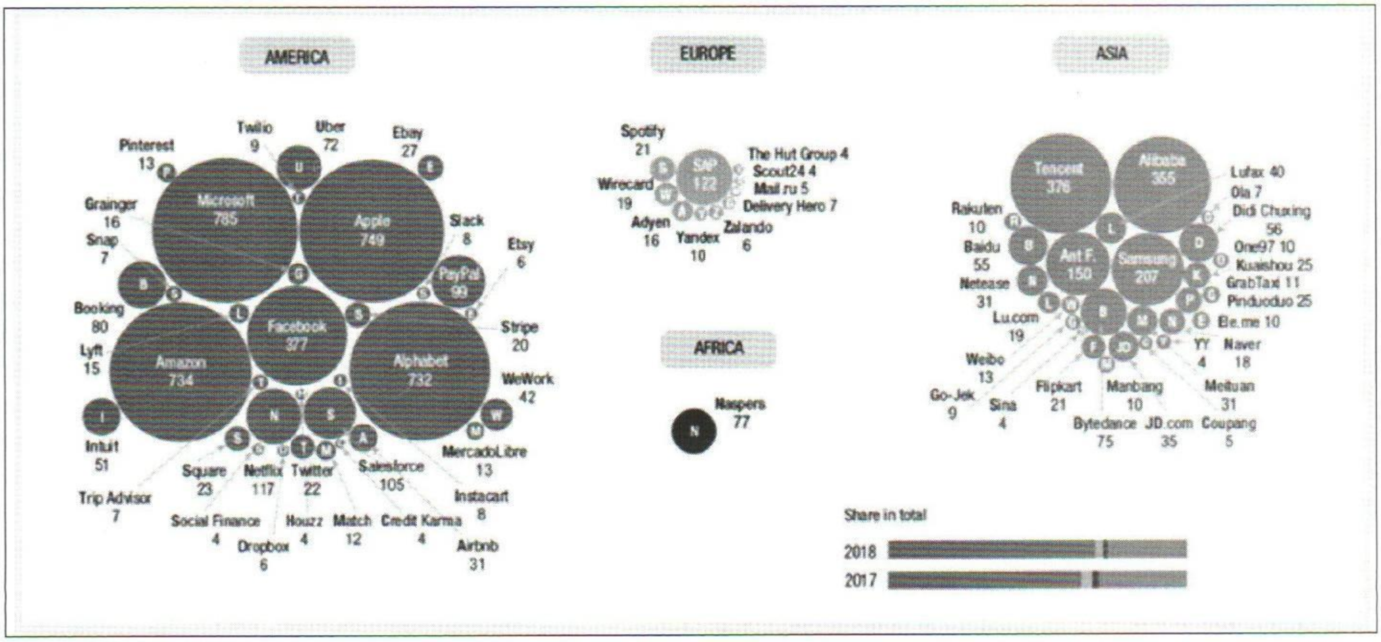
Figure 3: India's Digital Economy

3.1 Digital Platform Geography

The geographical distribution of the world's top digital platform companies is highly concentrated (Figure 4). Among the world's 70 highest-valued digital platforms, most are based in the United States, whose share increased from 65 per cent in 2017 to 70 per cent in 2018 (UNCTAD, 2019). Asia is the second-largest hub of global digital platforms; platform companies are relatively dispersed across the region with four major clusters— China, Northeast Asia, India and Southeast Asia—in the order of share in market cap (Evans, 2016). India has a smaller number of digital platforms, mostly privately owned. The two major Indian digital platforms are e-commerce companies, Flipkart and Snapdeal. In India, the platforms are concentrated in three major hubs: New Delhi, Bengaluru and Mumbai.

3.2 Value Creation in Digital Platforms

One of the most important components of value creation in the digital economy is data. Data is information which may or may not involve knowledge, because knowledge is specifically the usefulness of the information. But data,



Source: UNCTAD, 2019.

Figure 4: Geographical Distribution of the Major Digital Platforms in the World, 2018 (Market Capitalisation in Billions of Dollars)

in its material form, has an economic value, which needs to be extracted, recorded and maintained in massive storage systems, as well as organised, processed and analysed. Digital platforms play a pivotal role in creating value from data. According to Mayer-Schönberger and Cukier (2013), 'datafication' refers to the ability of digital platforms to render many aspects of the world into data that have never been 'datafied' or simply quantified before. Digital platforms monetise data or generate value for the platform owners, not just by 'demographic or profiling data volunteered by customers that are solicited from them in (online) surveys but also through behavioural metadata being automatically derived from smartphones through timestamps and GPS-inferred locations' (Van Dijck *et al.*, 2018). In other words, every aspect of human nature can be datafied and commodified (Couldry and Majeis, 2018). Value creation arises once the data is transformed into digital intelligence and monetised through commercial use (UNCTAD, 2019). Every bit of data in aggregation, in the form of Big Data, can be used for economic value creation through advertising, storage, etc. Ownership of data is equally concerning, as data is a new economic resource. From a development perspective, it becomes relevant to look at who can capture the value from this resource—not just the platform companies, but also the government for taxation purposes.

3.3 Employment and Work in the Digital Platform Economy

Value creation in the digital platform economy is also determined by how digitalisation affects employment and working conditions. Based on the consumption patterns, rising digital penetration and ever-increasing demand for digital platform services, the digital platforms offer unfettered potential in terms of the overall economy. But even though the global digital platforms are leading in terms of market capitalisation, their contribution to direct employment generation is less impressive. Yet, trends towards platformisation have led to the emergence of new forms of employment.

People in the labour force who generally opt for digital platforms are: (1) those who value the flexibility and autonomy (e.g. students, stay-at-home parents, retirees), and those for whom standard work is unsuitable; (2) the unemployed who cannot secure normal employment; (3) those who work full-time on one or multiple online talent platforms; and (4) fully employed individuals who seek to supplement their income (WSJ, 2015). Globally, a growing number of people are working for digital platforms on a demand basis, as independent contractors, self-employed and freelancers. India is emerging as the third-largest online labour market. Findings from the Online Labour Index survey 2016 show that India-based employers represented

5.9 per cent of all projects/tasks posting for online labour, of which 45 per cent were for software development and technology projects. This trend suggests the changing nature of employment, with freelancing emerging as an important megatrend shaping the IT-BPM industry (NASSCOM *et al.,* 2017). The platform economy has also encouraged the "need to acquire new skills to perform unfamiliar tasks" or "polish and refine existing skills while completing more familiar tasks" (Kittur *et al.,* 2013). Interestingly, the India Skills Report survey indicated the rising role of gigs in the economy at a 13 per cent share in the overall hiring intent by employment type (Wheebox, Tagged and Confederation of Indian Industry, 2020). The COVID-19 pandemic has also driven crowd work or work-from-home revolution, as suggested above.

Digital platform economy offers an unprecedented level of flexibility of work (amount of task) and time (number of working hours) to the workforce. It is true, that the flexibility and autonomy of the work in the platform economy may provide additional opportunities for individuals who struggle to enter the labour market and others who find it difficult to work at conventional times and places (Sundararajan, 2016). But the mere freedom to enter, work or leave a job does not make it flexible; rather, it is rendered more uncertain, insecure and precarious (Wood, 2016; Graham, 2017; Glöss *et al.*, 2016). Graham *et al.,* (2017) also suggest that low-paid and low-skill online work has the potential to disproportionately harm vulnerable individuals, particularly in the low- and middle-income developing countries. The flexible nature of work and unpaid leaves in the platform economy, in fact, motivate the precariat labour force to work overtime to earn that extra penny (Standing, 2013). ILO (2018c) notes that gig workers, on an average, work a greater number of unpaid hours and have difficulty in maintaining a work-life balance than those in traditional jobs. The work-from-home or remote work culture enforced during the pandemic has blurred work-time and leisure-time boundaries. Additionally, this flexibility has been accompanied by the latent 'disciplinary power' exercised by technology on platform labour (Foucault, 1977). For instance, the Uber application installed in the driver's smartphone acts as a panopticon in motion, disciplining, controlling and monitoring the drivers at all times (Sersia and Singh, 2020).

The rise in the flexible nature of the workforce has also opened a pandora's box of formal and informal economy debates. Regarding the contemporary labour market dynamics, increased flexibility induces new forms of control mechanisms and exploits the vulnerabilities of flexible labour through increased contractualisation and informalisation (Sersia and Singh, 2020). Interestingly, the report on the European legal framework for 'digital labour platforms' suggests, platforms have contributed to formalising the informal economy (De Stefano and Aloisi, 2018). However, while contract information, formal registration with a firm, etc. are indicators that make platform workers look like formal sector employees, these workers remain unprotected from untimely dismissals, insurance, the security of long-term payment and the retirement net. This means the digital platform labour also does not avail social security benefits such as minimum wages, paid leave, severance packages for loss of work, notice periods for job loss and contributions towards retirement. An example is platform labour involved in delivery during the pandemic. While the platform companies have found the pandemic an opportune moment to expand their operations, platform labour engaged in delivery have put themselves at considerable risk. Moreover, short-term and contractual employment relations, remotely controlled labour processes and atomised working conditions leads to diluted autonomy and bargaining power with fewer opportunities to exert their agency (Graham and Anwar, 2019).

This leads us to another important aspect of platform labour: how do negotiations work in this new form of employment relationship? Conceptualising the industrial relations of the platform economy, anecdotal evidence from (Kilhoffer *et al.,* 2017) suggests that no framework exists for social dialogue between the different parties involved in the platform economy. There are certain instances in which the platform economy is being incorporated into the broader system of industrial relations and social dialogue. But even if such a framework exists, it offers a poor fit due to differences among platform workers and employees, and platforms and employers. When the Ola/Uber driver-partners went on a strike in 2017 across metropolitan cities in a bid to press demands against low fares and long working hours, the Delhi High Court denied them the right to freedom of association and the right to organise, because the platform workforce is legally understood as independent contractors and not recognised as employees.

Across the European Union, the emergent employment relationship has been redefined as dependent self-employment (Williams and Lapeyre, 2017). But despite stipulating that workers have no employment relationship with the platform or client, many terms of service impose constraints on workers' autonomy that are not compatible with self-employment. Based on the aforementioned issues, the paper identifies three broad concerns in the context of digital platform labour: (1) recognition and definition; (2) remuneration and social security; (3) representation and unionisation (Figure 5).

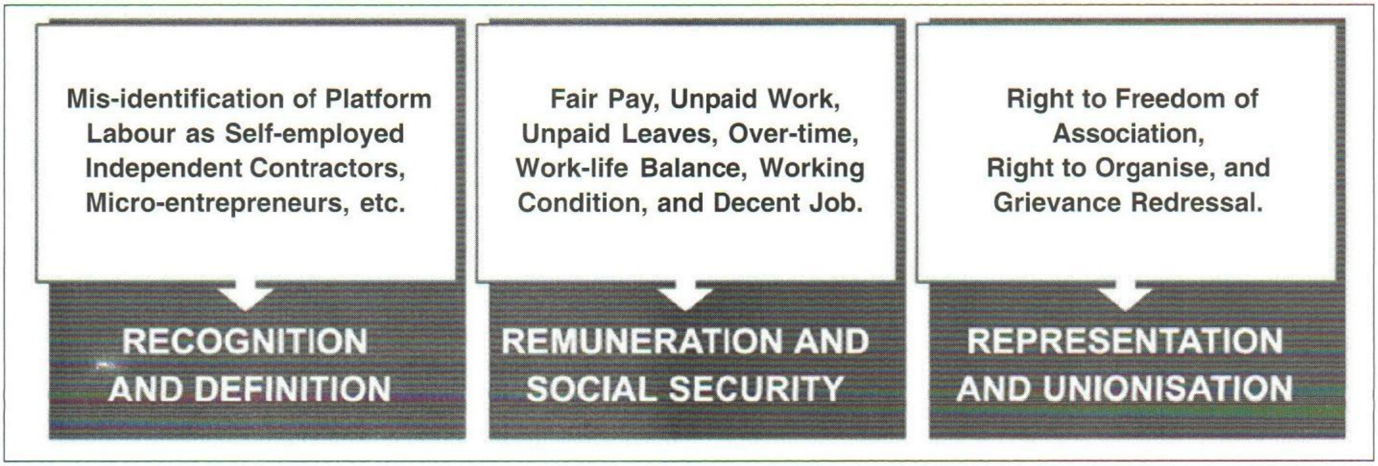


Figure 5: Issues and Concerns in the Context of Digital Platform Labour

4. Policy Perspectives

The new forms of employment entail work relationships that are distinctively different from the traditional or standard employment contracts (generally long or lifetime) which form the basis for existing social security arrangements. The new forms of employment are often not covered or are only partially covered under prevailing social security systems. It has thus become essential that the social security architecture is reoriented to include the new forms of employment in order to improve the quality of new jobs generated, and also to meet the growing employment aspirations of a youthful population.

In consonance with this imperative need, India's recently enacted Code on Social Security, 2020, recognises the need to bring new forms of work—like gig work and platform work—under the rubric of the country's social security systems. In a significant initiative, the Code states that the central government and state governments will set up social security funds and formulate schemes for meeting the important social security needs like life and disability cover, accident insurance, health and maternity benefits, and old age protection of gig workers and platform workers. With such a move, India becomes one of the first emerging countries to address the social security requirements of workers engaged in new forms of employment.

Importantly, the Code also makes provisions for registration of gig workers and platform workers, which is pivotal for evolving and maintaining a database on new forms of employment. This is critical as there is hardly any reliable information currently available on the number of persons engaged in such employment. The information generated can be very useful for planning and executing continuous skill upgradation of these workers, facilitating upward labour mobility and thus ensuring added income security.

The Code notes that schemes for gig workers and platform workers may be funded through a combination of contributions from the central government, state governments and aggregators. It proposes that aggregators contribute a minimum of 1 per cent of their annual turnover, going up to 2 per cent, as may be notified by the central government, to the social security fund. The Code, however, does put a cap on this, stating that this amount should not exceed 5 per cent of the amount paid or payable by an aggregator to gig workers and platform workers. The cap for aggregators is very fair considering that the degree of deductions in the organised sector is much higher. Such fairness reflects the endeavour to strike a much-needed balance between security to workers and flexibility to employers.

While formulating specific schemes to provide social security to those in platform and gig work, it may be useful to consider relevant international examples of harnessing digital technology to develop administrative and financing arrangements. In Uruguay, Uber drivers have access to a mobile app that ensures social security contributions are automatically deducted during fare transactions (ILO and OECD, 2018). Uber drivers in Sweden have the option of asking the company to facilitate their tax payment by sharing their fares and other information directly with the tax authorities on their behalf. In Malaysia, Uber drivers can carry out their annual pre-payment for employment injury schemes online (Behrendt and Nguyen, 2018).

One of the major issues associated with workers in the platform economy is the lack of collective voice representation. Trade unions could play a vital role in organising workers in these new forms of employment so that their rights are protected. This will also pave the way for sustaining social dialogue in the new forms of work. The policy architecture should also aim at facilitating work-life balance of those engaged in platform work. While promoting growth and diversification of the digital economy, it is equally vital to ensure this economy contributes to more and better jobs.

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Climate change brings pressures that will influence resource competition between nations and place additional burdens on economies, societies and governance institutions around the globe. These effects are threat multipliers.

– Barry Gardiner

Analysis of Productivity: A Comparative Study of Pharmaceutical Sector Companies Included in Nifty 50

MEENU MAHESHWARI AND PRIYA TAPARIA

Research Issue: *Productivity is the ratio of the output to the inputs used in the production process. In the present research, an attempt has been made to measure, analyze and compare intra-company and inter-company overall productivity of pharmaceutical sector companies from 2010–11 to 2017–18 i.e. for eight years.*

Research Findings: *For intra-company comparison, chi-square test has been used and the results indicate that null hypothesis drawn is accepted in case of Cipla Ltd., Dr. Reddy's Laboratories Ltd. and Lupin Ltd., while it is rejected in the case of Sun Pharmaceutical Industries Ltd. For inter-company comparison, Kruskal Wallis' One Way Analysis of Variance Test has been used and results indicate that null hypothesis is rejected. This means that there is significant difference in the productivity ratios of the pharmaceutical sector companies included in Nifty 50.*

Conclusion and Suggestions*: It may be concluded from the analysis that the pharmaceutical sector companies included in Nifty 50 are not able to utilize its resources efficiently as for each amount of input, less amount of output is obtained. Productivity of a company can be improved by optimally utilizing the raw material without any wastage or spoilage, the labour cost by adopting techniques such as incentive schemes, workers participation in the management, etc.*

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Introduction

Productivity is a measure whereby resources are combined and utilized effectively in the organization for achieving the desired goals. Productivity determines the efficiency of factors of production. Every plan of economic development and every idea behind industrial revolution is primarily based on the efforts of productivity increase. Productivity is not only necessary for enhancing the growth and development of an under-developed country but also for its existence. Productivity speeds up the process of quality production which further results in equal development.

Productivity and production are the connected terms used in the commercial environment. The efficiency of an organization in the production can be called as the firm's productivity. Productivity is a measure of how efficiently resources are combined and utilized in the organization for achieving the desired goals, while production is the function of an organization which is associated with the conversion of a range of inputs into desired outputs.

Productivity represents the ratio of output to input. It reflects how efficiently resources are being used in creating outputs. Hence, this study aims to measure productivity in aggregate terms of material, labour and overheads.

Review of Literature

Many studies on productivity trends in India and abroad have been carried out over the last few decades. Few studies are summarized below:

Agasisti, Munda and Hippe (2019) measured the efficiency (productivity) of European education systems by combining Data Envelopment Analysis and Multiple–

criteria evaluation. The main aim of the study was to analyze the spending of European compulsory education system and allocating ranks to the countries based on the efficiency scores given according to the spending. An innovative methodology has also been presented that combines the two methods namely Data Envelopment Analysis (DEA) and discrete Multiple-Criteria Evaluation (MCE). A set of common variables which are associated with the higher level of efficiency in education system has been identified in both the methods. The study has also concluded that the results given by the DEA method are more or less confirmed by the MCE method results.

Berg, Marrewijk and Tamminen (2018) investigated domestic and trading firm level data sets of Dutch and Finnish firms. Dutch firm's data over the period 2002-2010 while Finnish firms data covered for the period 2005-2010. The relationship between the trade status, productivity and profitability has been investigated in the present study. The predictions of two models, the Melitz Model and the Egger Kreickemerier Model have been analyzed to establish the relationship between the profit margins and the trade. Three hypotheses have been developed. First hypothesis was developed to analyze whether profit margins rise as productivity rises for domestic firms. The Melitz Model supports this hypothesis while the Egger Kreickemerier Model does not support it. Second hypothesis was developed to analyze whether profit margins rise as productivity rises for trading firms. Both the models supported this hypothesis. Finally, third hypothesis was developed to analyze whether profit margins are at least as high for domestic firms as of trading firms. The Melitz Model does not support it whereas it is supported by the Egger Kreickemerier Model. It has been recommended in the study that ways should be taken to adjust the Egger Kreickemerier Model, so it fits, in order to satisfy the first hypothesis.

Fattah (2015) investigated the impact of research and development spillovers on Egypt's domestic total factor productivity at the industry level. The study covers the database of 16 countries over the period 2003-2008. The regression analysis has been used to test for the presence of spillovers. The Hausman specification test has been applied to determine whether the fixed effect or the random effect model is more appropriate. The present study is concerned with the impact of research and development spillovers from various channels namely—import, export, inward FDI and outward FDI. The study has been concluded that the technology spillovers through FDI, whether inward or outward, have positive significant impact on total factor productivity. it has been demonstrated that the technology spillovers through imports have a negative impact on the total factor productivity whereas exports have a positive and significant impact on the productivity.

Degasperi and Fredholm (2010) examined in their paper a method of productivity accounting based on production prices. The foremost aim of this paper is to initiate an alternative method of productivity evaluation using input-output tables and production prices. This paper has also shown that how productivity accounting can be achieved without using an aggregate production function. It has also described an alternative way of productivity accounting based on the works of Von Neumann, Heontief and Sraffa on production system. The indices of labour productivity and technological progress have been constructed by utilizing the areas under the net national product and wage-profit curves respectively. This method is applied by the US, Germany, France and the UK. The study analyzed that the path of the technological progress and the growth rates in labour productivity has a significant difference between the US and the UK, and also between France and Germany.

Research Gap: As per the above reviews and many other studies related to the topic, there is no study on productivity of Pharmaceutical companies included in Nifty 50 for this particular study period. So, in this present research, an attempt has been made to measure the productivity of pharmaceutical companies.

Research Methodology

The various methods or ways adopted by the researcher in studying, comparing, analyzing and interpreting the research problem in accordance with the objective of research is known as the research methodology. It explains the different steps taken to solve the problem, test the hypotheses and interpret the results.

Main Objectives of the Research

The main objectives are summarized as follows:

1) To measure, analyze and compare the overall productivity of the pharmaceutical sector companies included in Nifty 50.
2) To compare the intra-company overall productivity for the study period.
3) To compare the inter-company overall productivity for the study period.

4) To suggest ways for improvement in their overall productivity.

Sample and Collection of Data

This research is based on secondary data. The data and information regarding output, sales, inputs and all other financial variables have been obtained from the annual reports of the respective companies, viz, Cipla Ltd., Dr. Reddy's Laboratories Ltd., Lupin Ltd., and Sun Pharmaceutical Industries Ltd. Data from the standalone financial statements have been used for purposes of analysis and interpretation. The index numbers used in the study have been collected from various bulletins published by the Reserve Bank of India on its website.

Selection of Base Year

The study covers a period of eight years i.e. from 2010-11 to 2017-18. The year 2010-11 has been taken as the base year. The revaluation of output and input is done as per the base year.

Period of Study

The present study covers a period of eight financial years from 2010–11 to 2017-18.

Hypotheses

Keeping in mind the objectives of the research, following hypotheses have been developed and tested.

Intra-company Hypothesis: The following intra-company hypothesis has been developed which will be tested and analyzed with the help of Non Parametric Test "Chi-Square Test".

Null Hypothesis (H_0): There is no significant difference in the overall productivity indices of the sampled company for the study period and can be represented by straight line trend or line of best fit.

Alternative Hypothesis (H_1): There is significant difference in the overall productivity indices of the sampled company for the study period and cannot be represented by straight line trend or line of best fit.

The acceptance of null hypothesis would reveal that the overall productivity indices of the sampled company for the study period are approximately equal. However, rejection of null hypothesis and acceptance of alternative hypothesis would mean that the overall productivity indices of the sampled company differ in the study period indicates that indices cannot be represented by straight line trend.

Inter-company Hypothesis: The following inter-company hypothesis has been developed which will be tested and analyzed with the help of Kruskal Wallis One Way Analysis of Variance Test.

Null Hypothesis (H_0): There is no significant difference in the overall productivity ratios for the sampled companies.

Alternative Hypothesis (H_1): There is a significant difference in the overall productivity ratios of sampled companies.

The acceptance of null hypothesis would reveal that the overall productivity ratios of sampled companies are approximately equal. However, rejection of null hypothesis and acceptance of alternative hypothesis would mean that the overall productivity ratios between the sampled companies differ.

Calculation of Index Numbers and Conversion Factors

Index numbers published by various RBI Bulletins and conversion factors accordingly have been used for the revaluation of data on the base year's prices for eight years from 2010-11 to 2017-18. Consumer price index for industrial workers has been used for revaluating labour input. Fuel and power index have been used for revaluating fuel and power expenses in the overhead input. And in rest of the cases, wholesale price index has been used for revaluation. Here, the year 2010-11 has been taken as base year. Backward Splicing technique has been used for calculating the index numbers of 2010-11.

Revaluation of Output

The output of the companies has been revalued by multiplying the output values with the conversion factors. Output includes sales, other income and change in the inventories of finished goods, work in progress and traded goods. Wholesale price index has been used for revaluating the output. Revalued output has been shown from the appendix 1 to 4.

Revaluation of Input

All inputs that is material, labour, overhead and investor input are added together and constituted the overall input. When overall input is compared with the output, it is known as the overall productivity. Different inputs have been revalued with the different index numbers according to the nature of the inputs.

Material Input: Material input consists of raw material and components, stores and spares, purchases of traded goods, and it is revalued with the wholesale price index.

The following formula has been used to calculate conversion factors:

Index number of the base year
Index number for the current year

Table 1: Index Numbers and the Conversion Factors for Revaluation of Data

Year	Wholesale Price Index	Conversion Factors	Consumer Index Index for Industrial Workers	Conversion Factors	Fuel and Power Index	Conversion Factors
	Base year 2011–12 = 100		Base Year 2001 = 100		Base Year 2011–12 = 100	
2010–11	91.80	1.000	180.00	1.000	87.75	1.000
2011–12	100.00	0.918	195.00	0.923	100.00	0.878
2012–13	106.90	0.859	215.00	0.837	107.10	0.819
2013–14	112.50	0.816	236.00	0.763	114.70	0.765
2014–15	113.90	0.806	251.00	0.717	107.70	0.815
2015–16	109.70	0.837	265.00	0.679	86.50	1.014
2016–17	111.60	0.823	276.00	0.652	86.30	1.017
2017–18	114.90	0.799	284.00	0.634	93.30	0.941

Source: Authors calculation with the help of RBI Bulletin

Labour Input: Labour input consists of salary, wages, bonus and benefits, contribution to provident and other funds and employees welfare expenses and others, and it is revalued with the consumer price index for industrial workers.

Overhead Input: All the remaining elements are covered under the overhead input. Overheads have been divided into major four heads: power and fuel, depreciation and amortization, repairs and maintenance and lastly business service input. Business service input includes all the other overhead expenses which are not covered under the above three heads. Power and fuel has been revalued with the fuel and power index. Repairs and maintenance and business service input have been revalued with the wholesale price index. Depreciation and amortization have not been revalued at all as they are valued on historical cost of fixed assets.

Investor Input: One more thing added to the input is the investor input. It is an additional cost for which the cost to the company is interest, royalty, profit, etc. Investor input is calculated by multiplying the base year rate of return with the average investment in succeeding years.

Average Investment: In the present research, assets approach is followed for calculating the capital employed or investment. Fixed assets have been taken on the historical values as shown in the balance sheet of the respective company. Non-current investments, long term loans and advances and other non-current assets, current assets, current liabilities, profit are revalued based on wholesale price index. Half of the profit has been deducted from the value of investment to obtain the average investment. Revaluation of Average Investment and Normal Investor Input of the companies of pharmaceutical sector has been shown from appendix 5 to 8.

Base Year Rate of Return: Total cost has been deducted from the output to obtain the base year returns. Total cost includes material, labour and overhead costs. The formula for the calculation of base year rate of return has been summarized as follows:

$$\text{Rate of Return (Company Standard)} = \frac{\text{Return}}{\text{Average Investment}} \times 100$$

The base year rate of return based on industry standard for intercompany comparison has been calculated with the help of the following formula:

$$R_I = \frac{R_1 + R_2 + R_3 + R_4 \text{ X } 100}{AI_1 + AI_2 + AI_3 + AI_4}$$

Where,

R_I = Rate of return (Industry standard)

R_1 to R_4 = Rate of return of sector companies

AI_1 to AI_4 = Average investment of sector companies

Table 2: Calculation of Rate of Return of Pharmaceutical Sector Companies in 2010-11 (Base Year)

S. No.	Particulars	Cipla Ltd.	Dr. Reddy's Laboratories	Lupin Ltd.	Sun Pharmaceutical Industries Ltd.
A	Output (Base Year) (A)	6308.14	5345.10	4510.95	3300.23
B	Total Cost (Base Year)				
1	Material	3085.90	1749.50	1921.18	928.85
2	Labour	464.20	701.20	491.23	214.06
3	Overhead	1852.99	1995.20	1228.24	699.95
	Total (B)	5403.09	4445.90	3640.65	1842.86
	Base Year Returns (R = A-B)	905.05	899.20	870.30	1457.37
	Average Investment (AI) (Base Year)	6369.13	6213.00	3211.93	6128.01
	Rate of Return (Company Standard) Rc =R/AI*100	14.21	14.47	27.10	23.78

Rate of Return is 18.85 %

Overall Productivity

Overall productivity of pharmaceutical sector companies has been shown from table 3 to 6.

Analysis and Interpretation

Output: The output of Cipla Ltd. is showing an increasing trend except in the years 2016-17 and 2017-18.

Normal Investor Input: It is showing an increasing trend. It lies between ₹1200.58 crore in 2010-11 and ₹2233.90 crore in 2017-18. It is calculated based on 18.85% on the average investment.

Total Input: Total input ranges from ₹6526.78 crore to ₹10423.34 crore. Its input-output ratio lies between 0.9945 and 1.1230. The lowest overall input-output ratio lies in the year 2015-16, which means that overall, it has been best utilized in this year.

Overall Productivity Ratio: There is an erratic trend in the overall productivity ratios of Cipla Ltd. It is 0.9552 in 2010-11, 1.0038 in 2011-12, 0.9684 in 2012-13, 0.9632 in 2013-14, 0.8904 in 2014-15, 1.0055 in 2015-16, 0.9122 in 2016-17 and 0.9185 in 2017-18. Overall productivity ratio is the lowest (0.9122) in 2016-17 while it is the highest (1.0055) in 2015-16. The highest ratio indicates efficiency and effectiveness while the lowest indicates that the overall input has not been utilized efficiently, and mismanagement may be responsible for the low productivity. Improvement in overall efficiency can also be observed from the average of overall indices which worked out to 99.68 as compared to the base year index of 100.

Testing Hypothesis and Interpretation: The standard deviation is 4.13 with 4.14% of variability of Cipla Ltd. The table value of chi-square at 5% level of significance with (8-1) = 7 degree of freedom is 14.067, while the calculated value of chi-square of Cipla Ltd. is 1.073. As the calculated value of chi-square is less as compared with the table value, null hypothesis is accepted while the alternative hypothesis is rejected. This reveals that the overall productivity indices of Cipla Ltd. for the study period are approximately same and can be represented by straight line trend or line of best fit.

Table 3: Overall Productivity of Cipla Ltd. from 2010-11 to 2017-18

Base Year 2010–11									Amount in ₹crore
S. No.	Items	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
1	Output	6308.14	6551.80	6992.95	7754.00	8004.10	10480.54	9185.26	9242.54
2	Material Input	3085.90	2706.24	2955.09	3266.28	3557.98	4003.52	3439.46	3585.25
3	Labour Input	464.20	672.14	811.29	980.26	1079.50	1215.17	1127.29	1132.29
4	Overhead Input	1852.99	1841.76	1982.17	2159.08	2530.24	3138.51	3394.14	3110.92
5	Total Input (Company Standard)	5403.09	5220.14	5748.55	6405.62	7167.72	8357.20	7960.88	7828.46
6	Normal Investor Input @ 18.85% (Industry Standard)	1200.58	1306.64	1472.46	1644.71	1821.17	2066.14	2108.97	2233.90
7	Total Input (Industry Standard)	6603.67	6526.78	7221.01	8050.33	8988.89	10423.34	10069.85	10062.36
8	Overall Input-output Ratio (Industry Standard)	1.0468	0.9962	1.0326	1.0382	1.1230	0.9945	1.0963	1.0887
9	Overall Productivity Ratio (Industry Standard)	0.9552	1.0038	0.9684	0.9632	0.8904	1.0055	0.9122	0.9185
10	Overall Productivity Indices (Industry Standard) (O)	100.00	105.09	101.38	100.83	93.22	105.26	95.49	96.16
11	Computed Value / Expected Values (E)	102.63	101.79	100.94	100.10	99.26	98.41	97.57	96.72
12	Chi-Square $(O-E)^2/E$	0.0674	0.1070	0.0019	0.0054	0.3675	0.4765	0.0443	0.0033

Average Overall Productivity Indices = 99.68, a = 99.68, b = - 0.42, χ^2 = 1.073, S.D. = 4.13, C.V. = 4.14 %.

Analysis and Interpretation

Output: The output of Cipla Ltd. is showing an increasing trend except in the years 2016-17 and 2017-18.

Normal Investor Input: It is showing an increasing trend. It lies between ₹1200.58 crore in 2010-11 and ₹2233.90 crore in 2017-18. It is calculated based on 18.85% on the average investment.

Total Input: Total input ranges from ₹ 6526.78 crore to ₹ 10423.34 crore. Its input-output ratio lies between 0.9945 and 1.1230. The lowest overall input-output ratio lies in the year 2015-16, which means that overall, it has been best utilized in this year.

Overall Productivity Ratio: There is an erratic trend in the overall productivity ratios of Cipla Ltd. It is 0.9552 in 2010-11, 1.0038 in 2011-12, 0.9684 in 2012-13, 0.9632 in 2013-14, 0.8904 in 2014-15, 1.0055 in 2015-16, 0.9122 in 2016-17 and 0.9185 in 2017-18. Overall productivity ratio is the lowest (0.9122) in 2016-17 while it is the highest (1.0055) in 2015-16. The highest ratio indicates efficiency and effectiveness while the lowest indicates that the overall input has not been utilized efficiently, and mismanagement may be responsible for the low productivity. Improvement in overall efficiency can also be observed from the average of overall indices which worked out to 99.68 as compared to the base year index of 100.

Testing Hypothesis and Interpretation: The standard deviation is 4.13 with 4.14% of variability of Cipla Ltd. The table value of chi-square at 5% level of significance with

Table 4: Overall Productivity of Dr. Reddy's Laboratories Ltd. from 2010–11 to 2017–18

Base Year 2010-11								Amount in ₹crore	
S. No.	Items	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18
1	Output	5345.10	6165.93	7280.11	7922.46	8225.15	8724.64	8487.52	7599.85
2	Material Input	1749.50	1948.82	2381.06	2248.41	2538.90	2534.44	2494.10	2549.29
3	Labour Input	701.20	799.41	952.59	904.08	1068.98	1161.09	1175.75	1168.46
4	Overhead Input	1995.20	2417.70	2568.31	2975.76	2917.24	3586.31	3375.57	3251.19
5	Total Input (Company Standard)	4445.90	5165.93	5901.96	6128.25	6525.12	7281.83	7045.42	6968.94
6	Normal Investor Input @ 18.85% (Industry Standard)	1171.15	1219.38	1254.01	1565.40	1798.46	2061.16	1963.19	2026.25
7	Total Input (Industry Standard)	5617.05	6385.31	7155.97	7693.65	8323.58	9342.99	9008.61	8995.19
8	Overall Input-output Ratio (Industry Standard)	1.0509	1.0356	0.9829	0.9711	1.0120	1.0709	1.0614	1.1836
9	Overall Productivity Ratio (Industry Standard)	0.9516	0.9656	1.0173	1.0297	0.9882	0.9338	0.9422	0.8449
10	Overall Productivity Indices (Industry Standard) (O)	100.00	101.48	106.91	108.21	103.85	98.13	99.01	88.79
11	Computed Value / Expected Values (E)	105.86	104.41	102.97	101.52	100.07	98.63	97.18	95.73
12	Chi-Square $(O-E)^2/E$	0.3245	0.0826	0.1510	0.4412	0.1422	0.0025	0.0344	0.5040

Average Overall Productivity Indices = 100.80, a = 100.80, b = - 0.72, $\div^2$ = 1.682, S.D. = 5.67, C.V. = 5.63 %.

(8-1) = 7 degree of freedom is 14.067, while the calculated value of chi-square of Cipla Ltd. is 1.073. As the calculated value of chi-square is less as compared with the table value, null hypothesis is accepted while the alternative hypothesis is rejected. This reveals that the overall productivity indices of Cipla Ltd. for the study period are approximately same and can be represented by straight line trend or line of best fit.

Analysis and Interpretation

Output: The output of Dr. Reddy's Laboratories Ltd. is ₹5345.10 crore in 2010-11, ₹6165.93 crore in 2011-12, ₹7280.11 crore in 2012-13, ₹7922.46 crore in 2013-14, ₹8225.15 crore in 2014-15, ₹8724.64 crore in 2015-16, ₹8487.52 crore in 2016-17 and for 2017-18 it is ₹7599.85 crore.

Normal Investor Input: The normal investor input of Dr. Reddy's Laboratories Ltd. is ₹1171.15 crore, ₹1219.38 crore, ₹ 1254.01 crore, ₹ 1565.40 crore, ₹1798.46 crore, ₹2061.16 crore, ₹1963.19 crore and ₹2026.25 crore respectively from 2010-11 to 2017-18.

Total Input: Total input is (the minimum) ₹5617.05 crore in the year 2010-11 as compared to (the maximum) ₹9342.99 crore in 2015-16. Its input-output ratio is (the maximum) 1.1836 in 2017-18 as compared to (the minimum) 0.9711 in 2013-14, respectively.

Overall Productivity Ratio: Overall productivity ratio is fluctuating in nature. It is the lowest (0.8449) in 2017-18 while it is the highest (1.0297) in 2013-14. The highest ratio indicates efficiency and effectiveness while the lowest ratio indicates that the overall input has not been utilized efficiently. Improvement in overall efficiency can also be observed from the average of overall indices which is 100.80 as compared to the base year.

Testing Hypothesis and Interpretation: The standard deviation of Dr. Reddy's Laboratories Ltd. is 5.67 with 5.63% of variability. For testing the hypothesis, the chi-square method has been used. The table value of chi-square at 5% level of significance with (8-1) = 7 degree of freedom is 14.067 while the calculated value of chi-square of Dr. Reddy's Laboratories Ltd. is 1.682. As the calculated value of chi-square is less as compared to the table value, null hypothesis is accepted and the alternative hypothesis is rejected. This reveals that the overall productivity ratios of the Dr. Reddy's Laboratories Ltd. for the eight-year period are approximately the same and can be represented by a straight-line trend or line of best fit.

Table 5: Overall Productivity of Lupin Ltd. from 2010-11 to 2017-18

Base Year 2010-11							Amount in ₹crore		
S. No.	**Items**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**
1	Output	1749.50	1948.82	2381.06	2248.41	2538.90	2534.44	2494.10	2549.29
2	Material Input	1921.18	2182.49	2512.11	2630.34	2830.58	3231.78	3289.47	3022.57
3	Labour Input	491.23	536.47	596.85	644.22	754.68	808.46	914.78	914.00
4	Overhead Input	1228.24	1403.97	1670.17	1812.80	1940.20	2343.51	2943.02	2595.72
5	Total Input (Company Standard)	3640.65	4122.93	4779.13	5087.36	5525.46	6383.75	7147.27	6532.29
6	Normal Investor Input @ 18.85% (Industry Standard)	605.45	675.79	798.00	1034.75	1330.45	1744.83	2243.76	2531.39
7	Total Input (Industry Standard)	4246.10	4798.72	5577.13	6122.11	6855.91	8128.58	9391.03	9063.68
8	Overall Input-output Ratio (Industry Standard)	2.4270	2.4624	2.3423	2.7229	2.7003	3.2073	3.7653	3.5554
9	Overall Productivity Ratio (Industry Standard)	0.4120	0.4061	0.4269	0.3673	0.3703	0.3118	0.2656	0.2813
10	Overall Productivity Indices (Industry Standard) (O)	100.00	98.57	103.62	89.14	89.88	75.67	64.46	68.26
11	Computed Value / Expected Values (E)	106.02	100.36	94.70	89.03	83.37	77.70	72.04	66.37
12	Chi-Square $(O-E)^2/E$	0.3422	0.0321	0.8408	0.0001	0.5086	0.0530	0.7978	0.0538

Average Overall Productivity Indices = 86.20, a = 86.20, b= - 2.83, χ^2= 2.628, S.D. = 14.03, C.V. = 16.27%.

Analysis and Interpretation

Output: The output of Lupin Ltd. is ₹1749.50 crore for the year 2010-11 and it reached ₹ 2549.29 crore in 2017-18.

Normal Investor Input: The normal investor input element of the total input of Lupin Ltd. lies between ₹605.45 crore in 2010-11 and ₹2531.39 crore in 2017-18.

Total Input: The total input of Lupin Ltd. shows an upward trend except in the year 2017-18. It is ₹4246.10 crore in 2010-11 and reached ₹ 9063.68 crore in 2017-18. Its input-output ratio is the lowest (2.3423) in the year 2012-13, indicating that overall input has been optimally utilized in this year. It is the highest (3.7653) in 2016-17.

Table 6: Overall Productivity of Sun Pharmaceutical Industries Ltd. from 2010-11 to 2017-18

Base Year 2010-11									Amount in ₹crore
S. No.	Items	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
1	Output	3300.23	3925.99	2283.03	2426.49	6888.78	6677.42	6699.57	7378.69
2	Material Input	928.85	1154.65	925.89	1031.91	2853.90	2971.54	3204.99	3039.36
3	Labour Input	214.06	292.18	196.59	213.36	1065.95	1005.27	977.92	1025.62
4	Overhead Input	699.95	774.62	612.30	1142.17	3267.67	3113.52	2508.79	2278.34
5	Total Input (Company Standard)	1842.86	2221.45	1734.78	2387.43	7187.52	7090.33	6691.71	6343.32
6	Normal Investor Input @ 18.85% (Industry Standard)	1155.13	1275.93	1307.79	1836.45	4278.33	4217.66	3726.87	3508.47
7	Total Input (Industry Standard)	2997.99	3497.38	3042.57	4223.88	11465.85	11307.99	10418.58	9851.79
8	Overall Input-Output Ratio (Industry Standard)	0.9084	0.8908	1.3327	1.7407	1.6644	1.6935	1.5551	1.3352
9	Overall Productivity Ratio (Industry Standard)	1.1008	1.1226	0.7504	0.5745	0.6008	0.5905	0.6430	0.7490
10	Overall Productivity Indices (Industry Standard) (O)	100.00	101.97	68.16	52.19	54.58	53.64	58.41	68.04
11	Computed Value / Expected Values (E)	89.74	83.99	78.24	72.50	66.75	61.01	55.26	49.51
12	Chi-Square $(O-E)^2/E$	1.1736	3.8505	1.2986	5.6910	2.2199	0.8886	0.1803	6.9317

Average Overall Productivity Indices= 69.62, a= 69.62, b = - 2.87, χ^2 = 22.234, S.D. = 18.99, C.V. = 27.28%.

Overall Productivity Ratio: Overall productivity ratio is showing an erratic trend. It is 0.4120 in 2010-11, 0.4061 in 2011-12, 0.4269 in 2012-13, 0.3673 in 2013-14, 0.3703 in 2014-15, 0.3118 in 2015-16, 0.2656 in 2016-17, 0.2813 in 2017-18. The highest overall productivity ratio in 2012-13 with 0.4269 indicates that overall input has been best utilized in 2012-13. Improvement in overall efficiency can also be observed from the average of overall indices which worked out to 86.20 as compared to the base year index of 100.

Testing Hypothesis and Interpretation: The standard deviation of Lupin Ltd. is 14.03 with coefficient of variation 16.27%. Chi-square has been used for testing the hypothesis and its table value at 5% level of significance with (8-1) = 7 degree of freedom is 14.067, while the calculated value of chi-square of Lupin Ltd. is 2.628. As the calculated value of chi-square is less as compared to the table value, null hypothesis is accepted and the alternative hypothesis is rejected. This reveals that the overall productivity ratios of Lupin Ltd. for the eight-year period are approximately the same and can be represented by a straight-line trend or line of best fit.

Analysis and Interpretation

Output: The output of Sun Pharmaceutical Industries Ltd. shows a fluctuating trend. Output in 2010-11 is ₹3300.23 crore, in 2011-12 is ₹3925.99 crore, in 2012-13 is ₹2283.03 crore, in 2013-14 is ₹2426.49 crore, in 2014-15 is ₹6888.78 crore, in 2015-16 is ₹6677.42 crore, in 2016-17 is ₹ 6699.57 crore and in 2017-18 is ₹7378.69 crore.

Normal Investor Input: The calculated normal investor input of Sun Pharmaceutical Industries Ltd. shows an increasing trend till 2014-15, and a decreasing trend after. It is the lowest (₹1155.13 crore) in 2010-11 while it is the highest (₹4278.33 crore) in the year 2014-15.

Total Input: Total input of Sun Pharmaceutical Industries Ltd. is showing a fluctuating trend. It is ₹ 2997.99 crore in 2010–11 and reached ₹ 9851.79 crore in 2017-18. Overall input-output ratio is the highest (1.7407) in 2013-14 while it is the lowest (0.8908) in 2011-12. The lowest ratio indicates that overall input has been optimally utilized during the year 2011-12.

Overall Productivity Ratio: It is the highest (1.1226) in 2011-12 while it is the lowest (0.5745) in 2013-14. Overall efficiency can also be observed from the average of overall

Table 7: Kruskal Wallis One Way Analysis of Variance Test of Pharmaceutical Sector Companies

Base Year 2010-11

Year	Cipla Ltd.		Dr. Reddy's Laboratories Ltd.		Lupin Ltd.		Sun Pharmaceutical Industries Ltd.	
	Ratio	Rank 1	Ratio	Rank 2	Ratio	Rank 3	Ratio	Rank 4
2010–11	0.9552	22	0.9516	21	0.4120	7	1.1008	31
2011–12	1.0038	27	0.9656	24	0.4061	6	1.1226	32
2012–13	0.9684	25	1.0173	29	0.4269	8	0.7504	14
2013–14	0.9632	23	1.0297	30	0.3673	4	0.5745	9
2014–15	0.8904	16	0.9882	26	0.3703	5	0.6008	11
2015–16	1.0055	28	0.9338	19	0.3118	3	0.5905	10
2016–17	0.9122	17	0.9422	20	0.2656	1	0.6430	12
2017–18	0.9185	18	0.8449	15	0.2813	2	0.7490	13
Total		**176**		**184**		**36**		**132**

H = 19.682

Table 8: Comparative Average Productivity Ratios from 2010-11 to 2017-18

Base Year 2010-11						
Companies	**Overall Input-output Ratio**		**Overall Productivity Ratio**		**Chi-square Test**	
	Average	**Rank**	**Average**	**Rank**	**Value**	**Rank**
Cipla Ltd.	1.0521	2	0.9522	2	1.073	1
Dr. Reddy's Laboratories Ltd.	1.0460	1	0.9592	1	1.683	2
Lupin Ltd.	2.8979	4	0.3552	4	2.628	3
Sun Pharmaceutical Industries Ltd.	1.3901	3	0.7664	3	22.234	4

indices which worked out to 69.62 as compared to the base year index of 100. This indicates that overall it is not being able to utilize efficiently as compared to the base year.

Testing Hypothesis and Interpretation: The standard deviation of Sun Pharmaceutical Industries Ltd. is 18.99 with 27.28% of variability. The table value of chi-square at 5% level of significance with (8-1) = 7 degree of freedom is 14.067 while the calculated value of chi-square of Sun Pharmaceutical Industries Ltd. is 22.234. As the calculated value of chi-square is more as compared to the table value, null hypothesis is rejected and the alternative hypothesis is accepted. This reveals that the overall productivity indices of the Sun Pharmaceutical Industries Ltd. for the study period are not approximately same and cannot be represented by straight line trend or line of best fit.

Kruskal Wallis One Way Analysis of Variance Test

The productivity of all the samples is combined and arranged in increasing order, given a rank number, and value of H is calculated and result indicated in table 4.

Testing Hypothesis and Interpretation: The calculated value of H is 19.682 and the table value is 7.815 at 5 % level of significance with 4 - 1 = 3 degrees of freedom. As the calculated value is more than the table value, the null hypothesis is rejected. This means that the overall productivity ratios of the pharmaceutical sector companies of Nifty 50 are not same and that is there is a significant difference in overall productivity.

Comparative Average Analysis

To analyze between the companies of a particular sector, it is better to analyze its average performance for the study period. In the present study, an attempt has been made to analyze and interpret the results based on average performance.

Analysis and Interpretation

Average Overall Input-output Ratio: The average overall input-output ratio is the best of Dr. Reddy's Laboratories Ltd. with 1.0460, followed by Cipla Ltd. with 1.0521, Sun Pharmaceutical Industries Ltd. with 1.3901 and lastly Lupin Ltd. with 2.8979.

Average Overall Productivity Ratio: Average overall productivity ratio is the best for Dr. Reddy's Laboratories Ltd. with 0.9592, followed by Cipla Ltd., Sun Pharmaceutical Industries Ltd. and Lupin Ltd.

Chi-square Test: On analyzing the chi-square of the pharmaceutical sector companies included in Nifty 50, it has been observed that Cipla Ltd. has the least chi-square value with 1.073, then Dr. Reddy's Laboratories Ltd., followed by Lupin Ltd., and lastly, Sun Pharmaceutical Industries Ltd. with the highest chi-square value 22.234. The table value of chi-square at 5% level of significance with (8-1) = 7 degree of freedom is 14.067. This shows that the null hypothesis based on the chi-square is accepted in case of Cipla Ltd., Dr. Reddy's Laboratories Ltd. and Lupin Ltd. while it is rejected in case of Sun Pharmaceutical Industries Ltd.

Conclusion

It may be concluded from the above analysis that the pharmaceutical companies included in Nifty 50 are not able to utilize its resources efficiently as for each amount of input less amount of output is obtained. Productivity of a company can be improved by improving the elements related to it. Material productivity may increase by optimally utilizing the raw material without any wastage or spoilage. Labour productivity can be improved by optimally utilizing the labour cost by adopting techniques such as incentive schemes, workers participation in the management, etc. Overhead productivity can be improved by reducing the expenses in overhead cost. Overhead cost such as power and fuel expenses can be reduced by using the CFL (Compact Fluorescent Lamp) in place of normal bulbs and tubes, as these are energy saving lights. Thus, this will result in improvement in overall productivity.

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"The waste of plenty is the resource of scarcity."

– Thomas Love Peacock (Author)

Appendices

Appendix 1 to 4: Revaluation of Output

Appendix 1: Revaluation of Output of Cipla Ltd. from 2010-11 to 2017-18

Base year 2010–11

Amount in ₹crore

S. No.	Items	2010-11	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18	
		Actual	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued
1	Revenue from Operations	6,135.16	6,977.50	6,405.35	8,202.42	7,045.88	9,380.29	7,654.32	10,131.78	8,166.21	12,034.06	10,072.51	10,974.58	9,032.08	11,444.81	9144.40
2	Other Income	298.72	148.30	136.14	229.13	196.82	280.28	228.71	147.91	119.22	259.14	216.90	129.85	106.87	334.88	267.57
3	Changes in Inventories of Finished Goods, Work in progress and Traded Goods	(125.74)	11.24	10.32	(290.75)	(249.75)	(158.12)	(129.03)	(349.05)	(281.33)	228.35	191.13	56.27	46.31	(212.05)	-169.43
	Total Output	6,308.14	7,137.04	6,551.80	8,140.80	6,992.95	9,502.45	7,754.00	9,930.64	8,004.10	12,521.55	10,480.54	11,160.70	9,185.26	11,567.64	9242.54

Appendix 2: Revaluation of Output of Dr. Reddy's Laboratories Ltd. from 2010-11 to 2017-18

Base year 2010-11

Amount in ₹crore

S. No.	Items	2010-11	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18	
		Actual	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued
1	Revenue from Operations	5249.10	6667.80	6121.04	8244.70	7082.20	9646.80	7871.79	9927.50	8001.57	10150.60	8496.05	9719.80	7999.40	9359.30	7478.08
2	Other Income	175.00	153.70	141.10	331.00	284.33	232.70	189.88	306.30	246.88	301.90	252.69	591.20	486.56	204.00	163.00
3	Changes in Inventories of Finished Goods, Work in progress and Traded Goods	-79.00	-104.80	-96.21	-100.60	-86.42	-170.60	-139.21	-28.90	-23.29	-28.80	-24.11	1.90	1.56	-51.60	-41.23
	Total Output	5345.10	6716.70	6165.93	8475.10	7280.11	9708.90	7922.46	10204.90	8225.15	10423.70	8724.64	10312.90	8487.52	9511.70	7599.85

Appendix 3: Revaluation of Output of Lupin Ltd. from 2010-11 to 2017-18

Base year 2010-11 | Amount in ₹crore

S. No.	Items	2010-11	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18	
		Actual	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued
1	Revenue from Operations	4508.50	5384.83	4943.27	7122.51	6118.24	8939.38	7294.53	9752.47	7860.49	11280.07	9441.42	12753.15	10495.84	10088.18	8060.46
2	Other Income	2.96	3.49	3.20	23.31	20.02	415.38	338.95	180.63	145.59	185.64	155.38	88.47	72.81	131.12	104.76
3	Changes in Inventories of Finished Goods, Work in progress and Traded Goods	-0.51	-132.53	-121.66	-182.44	-156.72	-76.21	-62.19	-170.80	-137.66	-172.72	-144.57	-185.26	-152.47	84.67	67.65
	Total Output	4510.95	5255.79	4824.82	6963.38	5981.54	9278.55	7571.30	9762.30	7868.41	11292.99	9452.23	12656.36	10416.18	10303.97	8232.87

Appendix 4: Revaluation of Output of Sun Pharmaceutical Industries Ltd. from 2010-11 to 2017-18

Base year 2010-11 | Amount in ₹crore

S. No.	Items	2010-11	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18	
		Actual	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued
1	Revenue from Operations	3104.07	4015.56	3686.28	2432.14	2089.21	2828.79	2308.29	8017.19	6461.86	7614.46	6373.30	7793.20	6413.80	7947.60	6350.13
2	Other Income	194.17	342.85	314.74	236.17	202.87	159.38	130.05	211.58	170.53	431.82	361.43	515.08	423.91	1128.04	
3	Changes in Inventories of Finished Goods, Work in progress and Traded Goods	1.99	-81.73	-75.03	-10.53	-9.05	-14.53	-11.86	318.10	256.39	-68.48	-57.32	-167.86	-138.15	159.26	127.25
	Total Output	3300.23	4276.68	3925.99	2657.78	2283.03	2973.64	2426.49	8546.87	6888.78	7977.80	6677.42	8140.42	6699.57	9234.90	7378.69

Appendix 5 to 8: Revaluation of Average Investment and Normal Investor Input

Appendix 5: Revaluation of Average Investment and Normal Investor Input of Cipla Ltd. from 2010-11 to 2017-18

Base year 2010-11 | Amount in ₹ crore

Items	2010-11	2011-12		2012-13		2013-14		2014-15		2015–16		2016-17		2017-18	
	Actual	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued
Fixed Assets	3120.72	3346.11	3346.11	3768.63	3768.63	3900.88	3900.88	3954.33	3954.33	4396.94	4396.94	4791.35	4791.35	4782.95	4782.95
Add: Non Current Investments	347.06	461.83	423.96	514.36	441.84	3328.28	2715.88	4036.99	3253.81	4317.81	3614.01	3647.71	3002.07	3597.24	2874.19
Add: Long Term Loans and Advances	435.50	385.65	354.03	373.72	321.03	535.30	436.80	576.71	464.83	772.61	646.67	524.61	431.75	604.21	482.76
Add: Other Non Current Assets	0.15	0.24	0.22	61.57	52.89	61.57	50.24	65.29	52.62	68.20	57.08	298.21	245.43	172.40	137.75
Add: Current Assets	4544.40	4799.96	4406.36	6774.93	5819.66	5097.97	4159.94	6558.50	5286.15	6463.90	5410.28	6345.34	5222.21	7938.17	6342.60
Total	8447.83	8993.79	8530.68	11493.21	10404.04	12924.00	11263.75	15191.82	13011.75	16019.46	14124.99	15607.22	13692.81	17094.97	14620.25
Less: Current Liabilities	1598.51	1179.74	1083.00	2264.60	1945.29	2416.74	1972.06	3566.26	2874.41	3081.20	2578.96	2555.83	2103.45	2731.70	2182.63
Net Capital Employed	6849.32	7814.05	7447.68	9228.61	8458.75	10507.26	9291.69	11625.56	10137.34	12938.26	11546.02	13051.39	11589.36	14363.27	12437.63
Less: Half of Profit (PAT)	480.20	561.98	515.90	753.56	647.30	694.17	566.44	590.55	475.98	699.01	585.08	487.47	401.19	734.26	586.67
Average Investment	6369.13	7252.07	6931.78	8475.06	7811.45	9813.09	8725.24	11035.02	9661.36	12239.25	10960.95	12563.92	11188.18	13629.01	11850.95
Normal Investor Input @ 18.85% Base Year Industry Standard	1200.58		1306.64		1472.46		1644.71		1821.17		2066.14		2108.97		2233.90

Appendix 6: Revaluation of Average Investment and Normal Investor Input of Dr. Reddy Laboratories Ltd. from 2010-11 to 2017-18

Base year 2010-11 — Amount in ₹crore

Items	2010-11	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18	
	Actual	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued
Fixed Assets	2237.00	2514.40	2514.40	2810.20	2810.20	3324.40	3324.40	3737.70	3737.70	5044.30	5044.30	5382.10	5382.10	5392.30	5392.30
Add: Non Current Investments	2462.00	2270.70	2084.50	2182.60	1874.85	1740.10	1419.92	1760.10	1418.64	1776.10	1486.60	1802.80	1483.70	1953.70	1561.01
Add: Long Term Loans and Advances	911.70	631.80	579.99	375.20	322.30	535.80	437.21	553.80	446.36	639.60	535.35	631.30	519.56	704.60	562.98
Add: Other Non Current Assets	0.00	0.00	0.00	20.90	17.95	0.00	0.00	1.10	0.89	2.70	2.26	37.20	30.62	11.20	8.95
Add: Current Assets	3652.70	4923.70	4519.96	6600.20	5669.57	8907.80	7268.76	10403.30	8385.06	10094.90	8449.43	8593.80	7072.70	9038.50	7221.76
Total	9263.40	10340.60	9698.85	11989.10	10694.88	14508.10	12450.30	16456.00	13988.65	17557.60	15517.93	16447.20	14488.68	17100.30	14746.99
Less: Current Liabilities	2603.70	3062.30	2811.19	4073.10	3498.79	4114.20	3357.19	4678.60	3770.95	4798.70	4016.51	4258.00	3504.33	4719.90	3771.20
Net Capital Employed	6659.70	7278.30	6887.66	7916.00	7196.08	10393.90	9093.11	11777.40	10217.70	12758.90	11501.42	12189.20	10984.34	12380.40	10975.79
Less: Half of Profit (PAT)	446.70	456.20	418.79	632.75	543.53	966.40	788.58	839.70	676.80	677.25	566.86	692.05	569.56	283.45	226.48
Average Investment	6213.00	6822.10	6468.87	7283.25	6652.55	9427.50	8304.53	10937.70	9540.90	12081.65	10934.56	11497.15	10414.79	12096.95	10749.32
Normal Investor Input @ 18.85% Base Year Industry Standard	1171.15		1219.38		1254.01		1565.40		1798.46		2061.16		1963.19		2026.25

Appendix 7: Revaluation of Average Investment and Normal Investor Input of Lupin Ltd. from 2010–11 to 2017–18

Base year 2010–11 | Amount in ₹crore

Items	2010-11	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18	
	Actual	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued
Fixed Assets	1796.72	2064.81	2064.81	2253.77	2253.77	2446.51	2446.51	2525.56	2525.56	2969.18	2969.18	3493.28	3493.28	4511.70	4511.70
Add: Non Current Investments	680.88	687.29	630.93	688.04	591.03	989.05	807.06	1790.26	1442.95	3740.82	3131.07	4801.92	3951.98	5130.26	4099.08
Add: Long Term Loans and Advances	307.05	380.51	349.31	362.03	310.98	319.70	260.88	239.45	193.00	271.57	227.30	85.53	70.39	208.44	166.54
Add: Other Non Current Assets	4.52	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.26	0.00	0.00	216.74	178.38	113.15	90.41
Add: Current Assets	2422.60	3026.10	2777.96	3741.89	3214.28	5043.70	4115.66	6452.12	5200.41	7235.33	6055.97	9250.77	7613.38	8717.45	6965.24
Total	5211.77	6158.71	5823.01	7045.73	6370.06	8798.96	7630.11	11007.71	9362.17	14216.90	12383.52	17848.24	15307.41	18681.00	15832.97
Less: Current Liabilities	1594.85	2035.66	1868.74	1857.15	1595.29	1461.32	1192.44	1659.99	1337.95	2293.55	1919.70	2565.61	2111.50	2336.21	1866.63
Net Capital Employed	3616.92	4123.05	3954.27	5188.58	4774.77	7337.64	6437.67	9347.72	8024.22	11923.35	10463.82	15282.63	13195.92	16344.79	13966.34
Less: Half of Profit (PAT)	404.99	402.19	369.21	630.22	541.35	1162.11	948.28	1198.68	966.13	1442.54	1207.40	1570.67	1292.66	672.33	537.19
Average Investment	3211.93	3720.87	3585.07	4558.37	4233.42	6175.53	5489.39	8149.05	7058.09	10480.82	9256.42	13711.97	11903.26	15672.46	13429.15
Normal Investor Input @ 18.85% Base Year Industry Standard	605.45		675.79		798.00		1034.75		1330.45		1744.83		2243.76		2531.39

Appendix 8: Revaluation of Average Investment and Normal Investor Input of Sun Pharmaceutical Industries Ltd. from 2010-11 to 2017-18

Base year 2010-11 | Amount in ₹crore

Items	2010-11	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18	
	Actual	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued	Actual	Revalued
Fixed Assets	990.04	1226.17	1226.17	1483.83	1483.83	1747.63	1747.63	4275.86	4275.86	4335.90	4335.90	5139.13	5139.13	5432.66	5432.66
Add: Non Current Investments	1778.59	3592.80	3298.19	3376.49	2900.40	6155.73	5023.08	25782.23	20780.48	22283.11	18650.96	19293.29	15878.38	18310.50	14630.09
Add: Long Term Loans and Advances	143.89	338.54	310.78	491.09	421.85	761.49	621.38	1895.23	1527.56	2165.47	1812.50	2637.86	2170.96	2878.33	2299.79
Add: Other Non Current Assets	0.19	2.83	2.60	7.83	6.73	0.11	0.09	41.95	33.81	61.75	51.68	410.80	338.09	395.36	315.89
Add: Current Assets	4693.89	3970.86	3645.25	3887.25	3339.15	5172.04	4220.38	5450.28	4392.93	5343.70	4472.68	6388.19	5257.48	6907.52	5519.11
Total	7606.60	9131.20	8482.99	9246.49	8151.95	13837.00	11612.56	37445.55	31010.63	34189.93	29323.72	33869.27	28784.04	33924.37	28197.54
Less: Current Liabilities	786.69	1018.52	935.00	1155.06	992.20	3706.07	3024.15	11052.08	8907.98	8838.78	7398.06	10962.65	9022.26	12243.49	9782.55
Net Capital Employed	6819.91	8112.68	7547.99	8091.43	7159.76	10130.93	8588.40	26393.47	22102.65	25351.15	21925.66	22906.62	19761.77	21680.88	18414.99
Less: Half of Profit (PAT)	691.90	848.75	779.15	258.28	221.86	-1414.26	-1154.04	-737.07	-594.07	-536.68	-449.20	-11.42	-9.40	-247.30	-197.59
Average Investment	6128.01	7263.94	6768.84	7833.16	6937.90	11545.19	9742.44	27130.54	22696.73	25887.83	22374.87	22918.04	19771.17	21928.18	18612.58
Normal Investor Input @ 18.85% Base Year Industry Standard	1155.13		1275.93		1307.79		1836.45		4278.33		4217.66		3726.87		3508.47

Public Space in the City of Allahabad, Uttar Pradesh: Uses, Misuses and Consequences

BHASKAR MAJUMDER

In India's transformation for urbanization by expanding economic opportunities and hence rising population in towns, absolute and as a percentage of the total population of the country, formation of slums is an immediate consequence. Most of these households who live at the bottom, construct a cluster of houses on land lying vacant that are known as slums. We examined the social matrix that facilitated the households to live in the slums in the city of Allahabad, Uttar Pradesh, and unobstructed the non-slum households to annex the public space in the city. We observed that both the slum households and the non-slum households lived in the same barometer of knowledge so far as public space was concerned. Parallel to the perceived unstable living of the households in slums, the state's intervention through demolition of structures built up by the non-slum households on public space for private purposes remained unquestioned in the city remodelling.

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Introduction

Almost all members of the income-poor households in India, since childhood, get engaged in unnumbered low-wage works simultaneously that nips their possibility of getting education in the bud. In the urban areas, these households live in slums where they do not own land and somehow construct a single-room house to live in. The immediate consequence of migration of the households from rural areas under distress to live in the urban space remains low-level living in the slums. This becomes inter-generational—from rural low-level living to urban low-level living.

We focused in this paper on the social matrix that facilitated the households to live in slums and unobstructed the non-slum households to occupy public space in the city of Allahabad. Based on pilot survey, we unearthed that most of the households migrated in the not-too-remote past from rural areas to work and live in the city of Allahabad. We took the following assumptions: (1) survival instinct forces almost all members of the slum households at an early age to get engaged in jobs; (2) the engagement of the slum household members at the bottom of the labour market reflects low-level living; (3) the non-slum households occupy urban public space depending on perceived opportunities.

We selected some indicators to comprehend the conditions of living of the slum households. In parallel, we tried to capture the social support, community support, and institutional support that they received. Juxtaposing, we observed the demolition of the buildings and shops constructed by the non-slum households on the public spaces of Allahabad and its impact.

The rest of the paper is structured as follows. In Section I, we present the methodology, sample, and the study zone. In Section II, we briefly present urbanization in India and the conditions of living in slums. In Section III we examine the interface of state and the living of the slum households in the city of Allahabad. In Section IV, we deal with state action and silence around slum and non-slum households in the city of Allahabad. Finally, in Section V, we sum up.

I. Methodology, Sample and Study Zone

We selected the city of Allahabad, one of the million-plus populated cities of Uttar Pradesh (UP). From the list of slums in existence in the city provided by the Allahabad Municipal Corporation, we selected one registered slum on the bank of Yamuna River based on pilot visits (DUDA, 2011). The registered slum was Dharkar Bastee, Kydganj, the land owned by the Government on the south of the city inhabited only by the Hindu population. We selected one unregistered slum namely, Jhuggi Jhopri Haddi-Godam, Kareli, at the centre of the city, the land owned by an individual, inhabited mostly by the Muslim population. We, thus, considered geographic location in selection of slums. We selected a core sample of 50 households, of which 30 were from the registered slum and 20 were from the unregistered slum. We selected a control sample of 25 persons from the non-slum areas in the city (Box 1).

Box 1: Study Zone and Sample Size

Zone	Number	Location
State	1	Uttar Pradesh
City	1	Allahabad
Name & Types of Slum	2	Registered Slum: Dharkar Bastee Unregistered Slum: Haddi-Godam, Kareli
Core Sample	50 Households	Registered Slum: 30 Households Unregistered Slum: 20 Households
Control Sample	25 Households	Non-Slum

We collected both quantitative and qualitative data through interviews of the households, observations, and Group Discussions (GDs). The core sample consisted of 58.0 per cent female respondents and the rest male. 62.0 per cent of the core sample households were Hindus (only SCs) and the rest Muslim. In the registered slum, all the selected households were SCs (Hindus); in the unregistered slum, all were Muslim excepting one Paasi (bottommost caste in Hindu). The average household size was six in the registered slum, and seven in the unregistered slum.

II. Urbanization in India and Living of Households in Slums

Due to rural-urban migration and natural increase of population, the population living in cities accelerates (UN-HABITAT, 2003). Urbanization shows rising density of population; it shows an increasing carrying capacity to attract population from outside through the increasing economic opportunities. The standard of living, in ascending order, distanced gradually from land-cum-agriculture dependence led to urban living due to increasing size of the population. Temporary shelters adjacent to the construction work sites in urban areas evolve where labourers are engaged. Depending on the nature and tenure of work, the mostly migrant labourers set up their make-shift rooms arranged in I-shape to either live individually or with family. Some of the labourers stay back in the urban space to form labour colonies, some of which ultimately take the shape of slums.

The literature on urbanization focuses on growth of urban areas by towns and cities, formation of slums, provision of public utilities and so on (Ramachandran, 1992; Kundu, 1994; Bhagat, 2011; Bhagat and Mohanty, 2009; Saxena, 2014). The combination of infrastructure, employment, education, and entertainment brings people to cities. 11.4 per cent of India's population lived in urban India during the Census 1901 which increased to 31.16 per cent in 2011 (Census, 2011). In UP, urban population as a percentage of total population remained much behind national average.

The not-readily-elastic urban space parallel to migration of the income-poor population from rural to urban gets reflected in formation of slums in cities. The Census of India 2001 defined a slum as a compact area of at least 300 in population or about 60 to 70 households living in dilapidated room-cum-house in an unhygienic environment with access to inadequate public utilities (Census, 2001). The Slum Area (Improvement & Clearance) Act, 1956, Government of India, defined slums as 'mainly those residential areas where dwelling are in any respect unfit for human habitation by reasons of dilapidated overcrowding, faulty arrangements and designs of such buildings, narrowness or faulty arrangements of streets, lack of ventilation, light or sanitation facilities or any combination of these factors which are detrimental to safety, health and morals' (GoI, 2010: 14). The UN-HABITAT defined a slum as a settlement where the inhabitants have inadequate housing and basic services (GoI, 2011: 10).

Living in Slums in the City of Allahabad

The households lived in suffocating dilapidated single-room houses with poor ventilation and absence of toilet; the houses were surrounded by narrow lanes, inadequate provision of street light, unsafe drinking water, prolonged water logging, foul water, foul smell, and overcrowding. The common wall of the living room separated one household from the other.

All the households, excepting one, in the registered slum migrated from Rewa, Madhya Pradesh; all the households in the unregistered slum migrated from Sahebganj, Jharkhand. Both the states are on the border of Uttar Pradesh. The households living in cluster of houses on land owned by the government did not take prior approval from the administration; they had no piece of paper as a legal document to claim that they leased-in the plot of land. The unregistered slum evolved in the recent past where 45.0 per cent of the households migrated two decades back. Economic needs forced people to move out and social network provided territorial direction to the migrants. The determinants of migration were job search and relocation of women through marriage.

The job search was never-ending, for, the slum dwellers were often engaged for paid wages and also self-engaged without wages. The occupations of the members of households living in slums were unnumbered, seasonal, and/or occasional, depending on the opportunities (Box 2).

Box 2: Occupations of Slum Households

Rag picking$^{\$}$, rickshaw pulling, plying E-rickshaw (battery-operated), assistant of auto rickshaw driver, trolley pulling, vegetable vending, sweeping, running tea shop and pan-masala (chewing leaf and tobacco) shop, domestic assistants, tailoring, basket making, beedi rolling, street hawking* and so on.

$^{\$}$ picking for sale to junk dealer.

* includes various types like those who only sell, those who buy discarded materials from households and sell to another buyer etc.

Source: Field Survey, 2016.

For many of the households, occupations were not regular and not fixed. They used to be self-engaged and hired in works as and when available. Almost all the members of slum households irrespective of age above infancy were engaged in unnumbered occupations simultaneously in the unorganized segment of the labour market. These uncertain occupations implied uncertain living of the slum households. The size of the household was large which forced every member to be an early starter in the labour market to supplement household income. Demographic necessity and early economic engagement led to the birth of a large number of children per couple, apart from household priority for sons for major regions of India, leading to natural expansion of slum population intra-city, reinforced by in-migration. The trade-off between education and job went against the former. Each individual remained engaged in multiple temporary occupations. Their income was linked to a number of factors like working hours, piece of work done, rent paid, *wassooli* (tax collected by a muscleman for non-obstructing business operations) paid, and location intra-city where they were allowed to operate. These locations were often competitive by being no-entry zones, as decided by the local administration, police, and the mafia. We did not find any distinction between major occupation and minor occupation for the slum households, implying absence of differences in main income and supplementary income for them.

The estimation of household income per year was difficult for the following reasons: (1) earning income was uncertain and irregular throughout the year; (2) any worker could withdraw from labour market anytime, (3) multiple employers, (4) seasonal employment, (5) self-engagement (non-wage based), (6) marriage of women workers, (7) many single-household workers.

Private and Public Utilities of Households in Slums

In the unregistered slum, 100 per cent of the households lived in rented houses on private land; in the registered slum on public land, all owned self-constructed house excepting one who rented-in. More than half of the houses were kutcha for both registered and unregistered slums. Other houses were semi-pucca; *Jhopri* was an exception. No house had toilet. 88.0 per cent of the households had no separate kitchen. 60.0 per cent of the households in the registered slum depended on tap water; 40.0 per cent in the unregistered slum used bore well. In each slum, 100 per cent of the households got electricity by *katiya.* In the registered slum, households used open space, while in the unregistered slum, households used community toilets for sanitation (Table 1).

Private Utilities of Households in Slums

Private Utilities		Registered		Unregistered		Total	
		Number	%	Number	%	Number	%
Types of House	Kutcha	16	53.3	10	50.0	26	52.0
	Semi-pucca	13	43.3	10	50.0	23	46.0
	Jhopri	1	3.3	0	0.0	1	2.0
Toilet	Absent	30	100.0	20	100.0	50	100.0
Space for Cooking	Inside House	5	16.7	1	5.0	6	12.0
	Outside House	25	83.3	19	95.0	44	88.0
Electricity	Katiya*	30	100.0	20	100.0	50	100.0
Drinking Water	Tap	30	100.0	0	0.0	30	60.0
	Bore well	0	0.0	20	100.0	20	40.0
Total Households		30	100.0	20	100.0	50	100.0

Note: *Accessing electricity directly from public electric line (extra-legal) for private consumption.

Source: Field Survey, 2016.

The sewage system was open and inner roads kutcha in both the slums. All the households disposed waste on the public space. Primary school was in proximity of each slum.

Institutional Support of Slum Households

The population from the households in the registered and the unregistered slum had social security cards like voter identity (ID) cards, Food Security Cards and Aadhaar. The slum households were socially marginalized for being low caste, landless, and income-poor. They remained incapacitated for deficit in both savings and education. They remained culturally delinked from the non-slum urban society. There was also inter-slum and intra-slum separation by castes that kept them demobilized. The upper caste households living in the same slum, by the same material standard, maintained distance from the households of lower caste to protect cultural purity.

The households living in slums, both registered and unregistered, did not own land where they built their houses. The slums as the living space were dirty and no-entry zone for the non-slum population. Inferiority was inflicted on the psyche of the slum households to silence them. The households in slums were afraid of the police, public administration, the slumlord, and the mafia. The households suffered from hypothetical errors of commission for their ignorance about the laws. The forms of intra-slum violence included physical clash, abusive language, *wasooli* (tax collected by a muscleman) and so on.

III. State and Slum Households: An Interface

The Government of India enacted The Slum Areas (Improvement and Clearance) Act, 1956, to examine if the slums were unfit for human habitation by reasons of dilapidation, overcrowding, faulty arrangement and design of such buildings, narrowness or faulty arrangement of streets, lack of ventilation, electricity and sanitation facilities, or any combination of these factors, are detrimental to safety, health or morals (GoI, 1956).

The Government of India launched the *Jawaharlal Nehru National Urban Renewal Mission (JnNURM)* on 3rd December, 2005 with the objectives of augmenting infrastructure facilities in cities and towns along with provision of shelter and basic civic services to slum dwellers and urban poor, in accordance with the 74th Constitutional Amendment Act, 1992.

The Government of UP announced the Uttar Pradesh Slum Areas (Improvement and Clearance) Act, 1962. This was amended as Uttar Pradesh Malin Basti Kshettra (Sudhar aur Nipataran) (Sanshodhan) Adhiniyam, 1981. This was further revised as Uttar Pradesh Malin Basti Kshettra (Sudhar aur Nipatan) (Sanshodhan) Adhiniyam, 1986. The 1986 Act maintained the power of the competent authority 'to serve upon the owner of the building an order directing him to demolish such building....' that was built 'without the previous permission of the Competent Authority...' (GoUP, 1986). The 1986 Act empowered the competent authority to acquire 'any land or building or both in a slum area or in a clearance area ......or for carrying out any order of demolition of building in that area or for the purpose of re-development of any clearance area or rehabilitation of the residents of slum areas....' (GoUP, 1986). The 1986 Act, thus, empowered the competent authority to take steps for acquisition of land, demolition of unauthorized buildings, clearance and improvement, rehabilitation of the slum residents, depending on the necessity announced in the official Gazette.

The Acts for improvement of slums in UP, by default, aimed at demolition of slums. The slum households had no idea about the existence of these Acts. The Notification for eviction of the slum households or re-development of the slum areas did not benefit them. The frontier between legality and extra-legality was often blurred in the perception of the slum households and the slumlords. Social living continued unabated beyond the frontier of law. The education-delinked living of the households grew along with the culture of poverty. Silence of the slum households, notwithstanding any injustice inflicted on them, kept them outside the orbit of being punished by the state. Loyalty of the slum households to the slumlord and to the public officials protected them in the slums. In exchange, the slum households had to supply cheap labour and occasionally unpaid labour for its protectors.

For the slum households in the city of Allahabad, congested housing, kutcha road, and absence of proper health care portrayed administrative apathy. Depending on the location of these slums, households had access to certain public utilities. The slumlord being the owner of the plot of land—where the slum households were allowed to construct houses—meant that the slumlord was the authority for the services provided to the slum households. Due to the slum households used to pay rent per house to a local muscleman who worked as the agent of the slumlord.

Sometimes slums cropped up on the vacant space where the households, unaware of the consequences, started building the house in parts over time depending on public reaction, attitude of the administration, and the capacity of the household to collect building materials. They built the houses made of discarded materials like polythene and waste papers. Public basic needs such as drinking water, sanitation and drainage often did not reach these households because the administration did not recognize these low caste, income-poor, politically demobilized households as one who could claim these basic needs. Because of migration, the households living in slums got culturally disintegrated from the people at their native place, making reverse migration impossible.

Interlinks between Slum Households, Slumlords, and the State

A tacit consent between the slumlord and the slum households in the unregistered slum—Haddi Godam at Kareli—was given access as the slumlord facilitated living of the households on the plot of land that he owned. The consent ensured benefits to both the slum households and the slumlord. The slum households relied on the slumlord for public basic needs for the apathy of the public officials. Due to the slum households never questioned the authority of the slumlord.

The slumlord used to operate through his agent. The slum households lived in solidarity, in a state of ignorance and fear. Lack of education kept them unaware of any rights-based claim over public resources. The households in both the slums used *katiya* (extra-legal connection) to access electricity; each household of the unregistered slum had to pay Rs. 100/- per month to the slumlord for this extra-legal benefit; the rent steadily increased over time. *Katiya* went unpunished as the slumlord was the protector of the free-riders, in collusion with the law enforcers.

The slumlord allowed the households in distress to live on the plot of land that he owned, which enabled him to escape the impact of imposition of land ceiling in urban areas. The slumlord protected the households from police and public administration; the slumlord also facilitated temporary extra-legal benefits for the slum households. The state remained silent in this matrix. The slumlord became the de facto administrator of the slum. The households in the registered slum Dharkar Bastee living on Government land never protested the injustice inflicted on them as they had already been disempowered by dispossession of whatever land that they had at their native place. They migrated to the city of Allahabad in search of economic opportunities. The administration remained indifferent to fulfil the public basic needs as the slum households were treated as unwelcome in-migrants from other states to the city of Allahabad.

IV. State Action and Silence: Some Implications

We talked to the non-slum households whose houses and shops were demolished totally or partially for restoration of public roads to its original plan in the city of Allahabad in 2018, under Smart City scheme of the Government of India. These non-slum households included mostly the business community, popularly known as '*Lalas*' in the caste-stratified city of Allahabad, though there were some Brahmins and *Thakurs* too. As reported by the administration, the process was restoration of original road-space that had been partially annexed by the encroachers. The public space shrank because of annexation by non-slum households for private purposes like small business, shops, and houses.

Often the process of annexation took time – it was a gradual move or stop-go, often with tacit consent of the local authority; the encroachers were accommodated into a soft social system. Often, political patronage stopped the eviction of the reserve army of voters for the polity. The alternative understanding could be that annexation varied in direct proportion with the capacity of the individual to annex. In some cases, the local *dabang* (muscleman) captured the space, known as '*kabja*' in local parlance.

Anti-Encroachment Drive

On 16th October 2018, the Government of Uttar Pradesh renamed the city of Allahabad as 'Prayagraj'. In parallel, the public roads of the city were being widened. The shops and residential buildings constructed on the public roads had been identified by the Allahabad Development Authority (ADA) for demolition, totally or partially, depending on the extent of encroachment.

The affected owners of houses/shops informed that the ADA assured to pay compensation for the structures demolished if these were on private land. For demolition of structures made on leased land or public land, no compensations were to be paid. For this demolition drive, the owners of shops and residential buildings were served prior notice; as was alleged, some persons did not receive that notice. Those uninformed by notification were informed orally by the representatives of the ADA that their buildings would be demolished after identification of the public space annexed by them. Most of the structures were demolished by the ADA and some were demolished by the encroachers themselves at their own cost. In case of the demolition drive undertaken by the ADA, a demolition-cost was imposed on the encroacher. The ADA officials opined that no prior notice or compensation for the demolition of the illegal constructions on the public space was required. The affected households informed that this anti-encroachment drive had the approval of the High Court. As they reported, the writ petitions filed against the demolition drive were dismissed by the High Court of Allahabad.

What more came under the demolition drive were public buildings of religious faith; this mirrored that the public space had been annexed in the past for construction of public buildings. Many of the temples that were demolished did not have any permanent *pujari* (priest). Many unnamed temples on the roadside of Jhusi on the east of Shastri Bridge were demolished. Adjacent to the Sohbatiya Bagh Dot Bridge near Sangam Petrol Pump, a Sai temple constructed in 2011, a Bajrangbali Temple and a Durga Temple were also demolished. Adjacent to the Sachan Nursing Home, an old Pahalwan Baba Temple was demolished. In Teliarganj, a Hanuman temple built in 1965 was demolished. In Phaphamau, in the north of the city of Allahabad, a century-old Shiva temple was demolished. In the restoration of public roads, many of the trees with stones coloured with vermilion and symbols of deities placed at the bottom of these trees for worship in the tradition of Hindu religion, were felled.

The preparations for Kumbh Mela (crowd for religious-cultural purposes), 2019, needed demolition of identified mosques and temples that annexed public space. The reasons and impact of the demolition drive were the following:

1. Many of the temples constructed on public roads were idols of Hindu God like Hanuman, installed under a tree. Many of these temples had no fulltime priest.
2. During and post-demolition of the temples, most of the priests could not be traced.
3. Many of the devotees expressed concern over the way the buildings of religious faith were demolished.
4. The demolition affected the livelihood of the vendors and shop owners selling garlands, sweets, and fruits in the locality.

In Jhusi, on the east of the city of Allahabad, the District Collector held a meeting adjacent to *paani ki tanki* (concrete water tank) with the local inhabitants whose houses or shops were to be demolished. The Collector asked for legal documents to prove possession of the plot of land on which those houses or shops were built. The owners of houses could prove the construction of houses and shops at their own cost, but failed to prove the ownership of the land. Many of these houses or shops were built decades back. One *dharna* (assembly of people to exercise their rights) was also made by the stakeholders in front of Jhusi police station. However, the constructed houses, totally or partially, were demolished following administrative order. The demolition drive not only affected those who owned the houses but also those who rented-in, those who bought total or part of that house from the first owner who constructed it on public land.

Because of the non-availability of the owners of houses-cum-shops being demolished in Jhusi area, we conversed with the labourers engaged in demolishing the buildings. The labourers could not reveal much. We asked a boy in his teens if his father, whose shop was being demolished, got compensation (money) or its assurance from anybody (administration). His response was, '*hum logo ko rupeea dena padega*' (we will have to pay money for demolition). The fact could not be verified.

The demolition work went simultaneously in areas like Sobtiyabag, Teliargunj, Bairana, Belli Road, Chowk and Jonsengunj Chouraha. The demolition was 'caste-community-gender-poverty'-neutral. The demolished shops on the roadside included medical store, grocery shop, sweetmeat shop, cloth shop, and bakeries. The boundary wall of Government-run TB Hospital was also demolished along with the boundary wall of Boy's High School near Mayo Hall Chouraha.

As we conversed with the unaffected persons from the groups standing to observe demolition-in-motion, the common response was '*Pahle abaidh kabja hua*' (initially the land was grabbed illegally). None of the owners of pucca buildings for residential-cum-commercial purposes that were demolished were slum dwellers. The *abaidh kabja,* thus, was not slum-specific. The silence of the non-slum households showed that their attitude was similar to that of the slum households in the city of Allahabad, in the face of crises.

The demolition drive by the administration in the city of Allahabad for restoring the public roads to its original plan implied delayed compliance with law, forcing encroachers to understand the impact of enforcement of law and the capacity of law. Both the encroachers and the non-encroachers were afraid of law for ignorance and unpredictable state action.

Some Implications

Post-demolition, many owners of shops continued business in *jugaar* (somehow managing) mode that included shops for intoxicants, tea stalls, and furniture shops. The meat shop made of tin roof and wooden wall, earlier operating on the public road, was observed to have been carried away elsewhere putting it on a cycle cart with some bamboo support at the bottom—implying low-cost transport. Some of such relocations implied that the small business operators, post-demolition or just ahead of it, were trying to relocate nearby to minimize private cost of operations, known market, and maintaining living-cum-business space.

We observed silence of the non-slum households whose houses/shops were demolished in the city, and the general silence of civil society organizations. Silence also made it obscure if the land that was occupied to build up houses, shops and temples actually belonged to the state. The administration implemented the state policy to restore original public space as per records, that had been captured (*kabja*) by the individuals. In case the annexation occurred long back, the annexed land had been conjectured as a right by the present successors who had no knowledge of property rights. The households reaped benefits as rental income and other means over a long period of time, due to this annexation of public space. Silence of these households either showed their ignorance or hidden acceptance of the violation of rules.

Silence prevailed when the public space, though privately occupied, was restored by the administration. One explanation of silence was specific to the culture of the *rurban* (rural-urban) city of Allahabad; this culture reflected the heartland—its sub-optimum functioning of civil society organizations. The other explanation could be the rent-seeking mindset of the people, leisurely attitude, dependence on polity, '*jugaar*', and self-glorification by concealment.

In an absence of informed property-rights, the urban individuals in India often grab public space to operate small businesses for private benefits; the benefits vary in direct proportion with the time-span they run the business, evading the eyes of public administration. The latter often did not take notice of such extra-legal annexation of public space. Unless and until the public need, as understood by the Government, is realized, the private annexation of public space goes unabated. The public space is commonwealth—it is annexed by some that hardly care about the public cost of that annexation.

Most of the respondents were not confident in comprehending the private-public differential. They annexed anything that they thought could be annexed, without bothering about the consequences by generations of negative externalities. The first victim became, in the process, the commons. Silence of the competent authority helped the encroachers. The question comes, otherwise how could the buildings/shops be built up on roads and operated over decades? And how did the city administration shut its eyes on the face of demolition of buildings that it probably authorized for construction in the not-too-remote past?

v. Summing Up

The social matrix that facilitated the slum households to live on—either private land of the slumlord or public land—reflected social equilibrium. The annexation of public space by the non-slum households also reflected a social equilibrium, until that was disturbed because of state intervention. The slums' social equilibrium centred on multiple occupations of most of the members of slum households and the public utilities they had access to, and social-community support they had for livelihood security. They had no opportunity of reverse migration to the rural areas.

The social equilibrium that was manifest in slum living was not readily revealed for the non-slum households who faced the impact of restoration of public space that the latter partially occupied. Silence was essence for slum social equilibrium; non-resistance by the non-slum households was the essence, when booted out by the administration. Silence was the common factor that maintained social general equilibrium in the city of Allahabad.

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> *Sustainable development requires human ingenuity. People are the most important resource.*
>
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