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Sustainable Solid Waste Management by Integration of waste at Taluka level - A Case study of Nadiad, Gujarat

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ABSTRACT: According to the 2011 census data, 68.84% of the total population in India live in rural areas. Development process without involvement of rural India is an asymmetrical. It has been observed that the majority of studies on solid waste management in India have now been carried out on large-scale cities and medium-scale towns, while less attention has been paid to small-scale towns and their surrounding villages. which will leads into unscientific disposal of municipal solid waste through open dumping in low-lying area or dumping waste near to the water bodies and by many other inappropriate ways. which will tends into serious environment problems & unfavorable impacts on health of surrounding habitation. Through present study emphasis have been made towards rural & semi-rural areas of Nadiad Taluka, in which major amounts of generated waste is decomposable. The efficiency of Municipal Solid Waste Management (MSWM) in Nadiad taluka can be enhanced through Integration of waste by forming clusters of villages and small scale towns through route optimization particularly for inert waste, generated decomposable waste can be directly decomposed through vermicomposting facility and recyclable waste can be recycled by recycle industries. This can be seen as a sustainable solution to the successful management of the MSWM facility.

Keywords: Cluster formation, Cost efficiency, Integrated solid waste management, Rural and semi-rural areas, Route optimization, Sustainable solid waste management.

I. INTRODUCTION

Municipal solid waste management continues to be a major issue nowadays in small and medium-scale towns and their neighboring villages in developing countries like India. At present landfills and open dump are the most common in developing countries, while in developed countries they are giving priorities is to given waste-to-energy, waste recycling and many other advanced options towards effective and sustainable disposal of Municipal Solid Waste [1]. Since there is an increase in population and modernization in small scale towns & rural areas, which has increased generation of solid waste; the amount of MSW is projected to increase dramatically in the near future as the country strives to attain an industrialized nation status [2].

According to Annual review report 2015-16 by CPCB 1,35,198.27 TPD Solid Waste is generated from all States of India, where 1,11,027.55 TPD waste is collected, only 25,572.25 TPD waste is treated and 47,415.62 TPD waste land filled. Which will reveals that there is an enormous gape between the amounts of total waste generated and amounts of total waste treated. It will indicates poor performance of acceptance of various MSWM Rules and Guidelines. India is facing an ever substantial challenge for providing the incremental Infrastructural needs for Solid Waste Management.

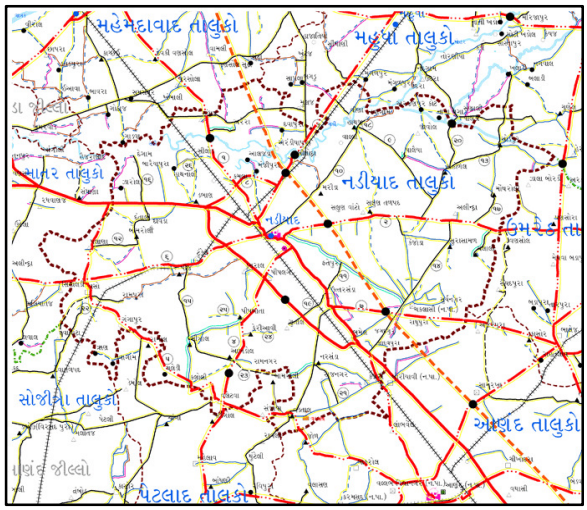
II. PRESENT SCENARIO OF SOLID WASTE MANAGEMENT IN STUDY AREA NADIAD TALUKA OF GUJARAT STATE

Nadiad Taluka of Kheda district having area of 404.06 Sq.km, which includes 59 villages and 3 Towns [3]. Through Primary data collection of selected villages and Towns of Study area. It has been noted that the majority of the solid waste produced is disposed of non-scientifically without proper treatment, such as near water sources, open government vacant land on the side of the road and in an open drainage system, and many other inappropriate ways. This may have serious adverse effects on the environment and the health of living beings.

III. STUDY AREA: NADIAD TALUKA

Nadiad Taluka is located in Kheda district of Gujarat, India. It is one of 10 Taluka of Kheda district. There are 59 villages and 3 towns in Nadiad Taluka. The Nadiad Taluka district has acquired its name from the town Kheda also known as Kaira. It is a very ancient town situated near the confluence of the rivers of Vatrak and Shedhi. Nadiad Taluka is the district head quarter for the Government administration. Tobacco processing is an important business here and it is actually the largest market in the district and the second largest market in the state of Gujarat. Nadiad Taluka is also the main

industrial Centre of the district. Gradually it became a hub for education and employment [4].



(**Source:** Website of Nadiad taluka panchayat)

Fig. 1. Map of Nadiad Taluka.

IV. CHARACTERIZATION OF WASTE IN NADIAD TALUKA

The amount of solid waste generated in the villages of Nadiad Taluka is relatively small. In addition, the significant quantity of waste generated from villages is decomposable. It has been analyzed that the average rate of waste generation based on selected villages of study area is 84.94 gms/capita/day with a composition of 68.1 % of waste is decomposable, 23.7% is recyclable and 8.2% is inert waste. The Average rate of waste generation in the small scale town Chaklasi & Kanjariis 111.62 gms/capita/day. Under which 59.5 % of waste is decomposable, 27.2 % of waste is recyclable and 13.3 % of waste is inert.

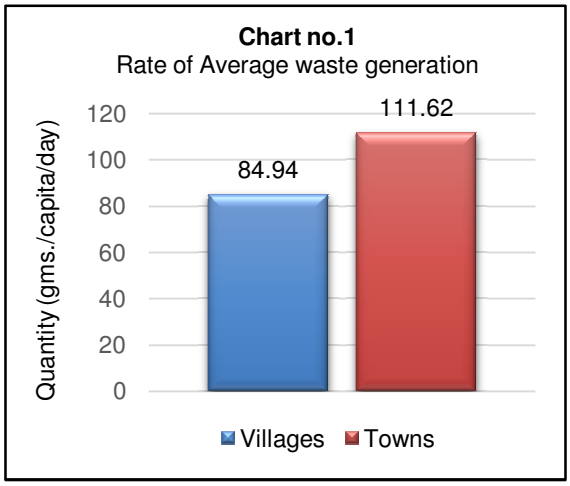


Chart no. 1: Average waste generation rate based on selected Villages & Chaklasi, Kanjari towns in the study area (Source: Primary data collection).

Note: All the above & below primary data collected relates to month of August 2018 to so on and All the primary data collected as the rate of generation of waste, the composition of waste, income basis generation rate, may be subject to change in terms of time and other related factors.

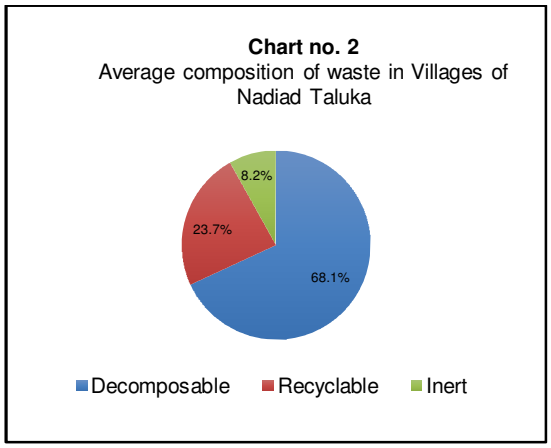


Chart no. 2: Average composition of generated waste in Villages of study area based on selected Villages. (Primary data collection).

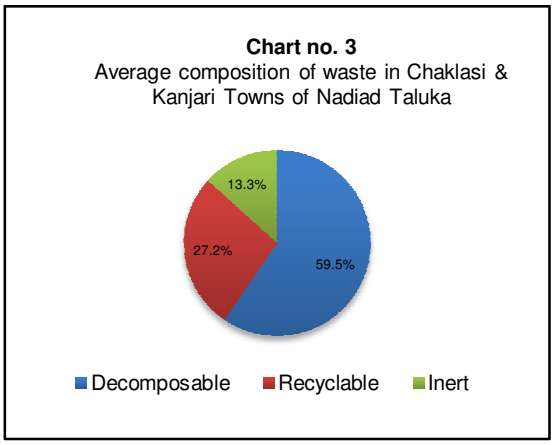


Chart no. 3: Average composition of generated waste in Chaklasi & Kanjari towns of study area (Primary data collection).

V. INTEGRATED SOLID WASTE MANAGEMENT

Here emphasis has been put on the integrating of waste through the creation of clusters of small towns and their neighboring villages by route optimization& considering local on ground criteria. Nadiad Taluka has 59 villages and 3 towns, Primary data collection has shown that the quantity of waste generation in rural areas and towns is less. In addition large amounts of waste generated in these areas are decomposable. As a result, the quantity of discarded waste is further decreases. In accordance with that the operation of solid waste management facilities such as daily collection, segregation, transport & disposal is not feasible and becomes difficult although it is not financially viable to manage in each village. As a matter of fact, it has been discovered that the cost of land and building costs are very high when sorting sites are set up in each villages. Hence implementing of integrated solid waste management would prove to be a technologically, financially and environmentally viable option.

VI. SOLUTION FOR INERT WASTE

Inert materials are unreactive, both biologically and chemically. This means that when inert waste is disposed of it takes a long time to decompose or doesn't decompose at all. This type of waste will not pose a threat to the environment, animals or human health and will not endanger the quality of water courses. But when there is a large amount of this type of waste, it can become an issue as it takes up a lot of space. Inert waste includes building (demolition) waste, gravel, sand, and stone but not any biodegradable, hazardous, or green (botanical) material.

Through Primary data collection, it was observed that the quantity of inert waste generated is about 8-15 percent of total waste. Through cluster formation with route optimization, this can be directly scientifically landfilled, thus proving to be an economically viable and sustainable approach to the management of the Solid Waste Management Network.

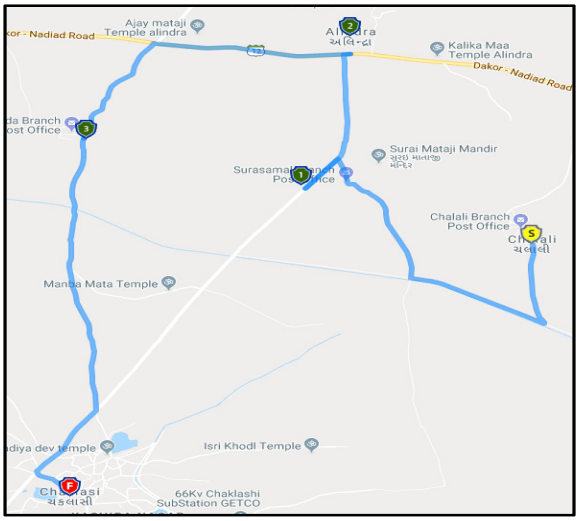
***A. Route optimization through driving route planner for inert waste disposal*:**

All routes for inert waste disposal are planned by the **driving route planner** on the basis of distance-based parameters and the amount of waste to be managed and the local on-site criteria being considered.

(Note: C indicates cluster number, R indicates Route number)

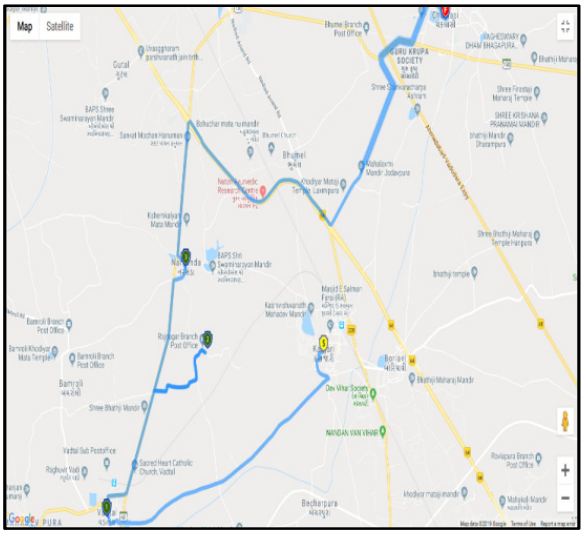
1. Chaklasi Cluster, C1R1 (Cluster no. 1, Route no. 1)

C1R1 Route, Chaklasi cluster.



C1R1 : Chalali to Chaklasi	
Cluster Head	Chaklasi
Via	Alindra, Surasamal, Kanjoda
Total villages covered	4
Route length	14.3 Km
Total Inert waste to be carry	1250 Kg/ Week

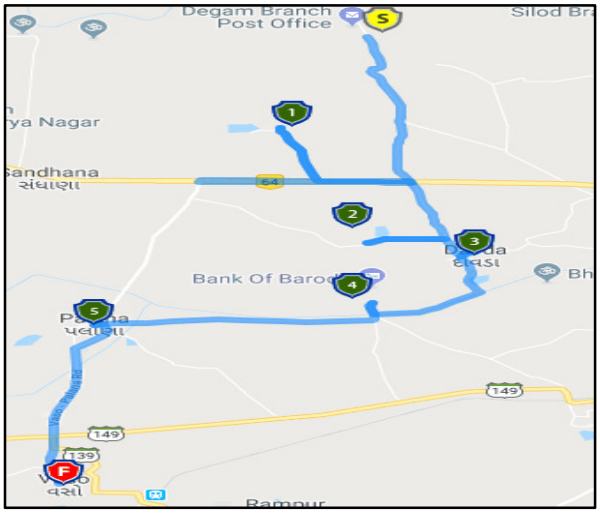
C1R2 Route, Chaklasi cluster.



C1R2 : Kanjari to Chaklasi	
Cluster Head	Chaklasi
Via	Vadtal, Rajnagar, Narsanda
Total villages covered	4
Route length	23.1 Km
Total Inert waste to be carry	2400 Kg/week

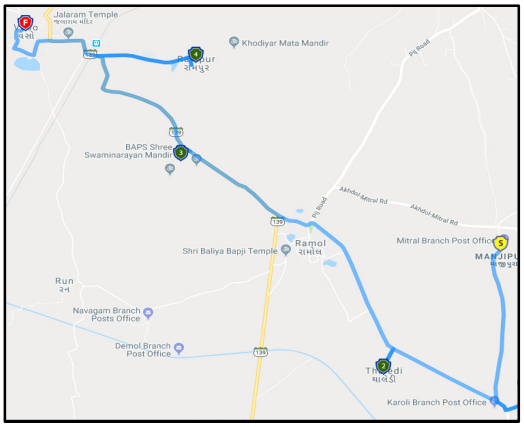
2. Vaso Cluster, C2

C2R1 Route, Vaso cluster.



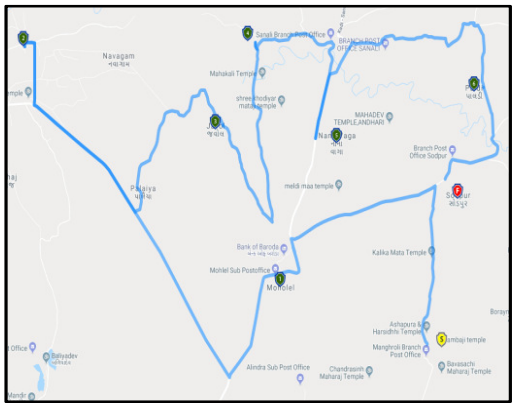
C2R1 : Degam to Vaso	
Cluster Head	Vaso
Via	Zarol, Dantali, Davda, Bamroli, Palana
Total villages covered	6
Route length	21.1 Km
Total Inert waste to be carry	1220 Kg/Week

C2R2 Route, Vaso cluster



C2R2 : Mitral to Vaso	
Cluster Head	Vaso
Via	Kaloli, Thaledi, Gangapur, Rampur
Total villages covered	5
Route length	16.2 km
Total Inert waste to be carry	740Kg/Week

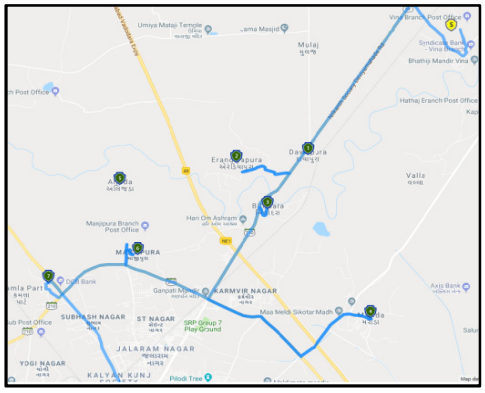
3. Sodpur cluster, C3



C3 : Monghroli to Sodpur	
Cluster Head	Sodpur
Via	Maholel, Navagam, Javol, Arajanpurkot, Nana vaga, Paldi
Total villages covered	7
Route length	38 km
Total Inert waste to be carry	12350 Kg/Week

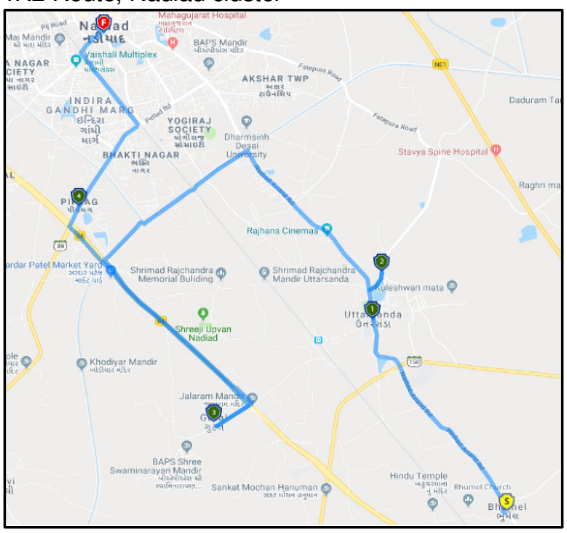
4. Nadiad Cluster, C4

C4R1 Route, Nadiad cluster



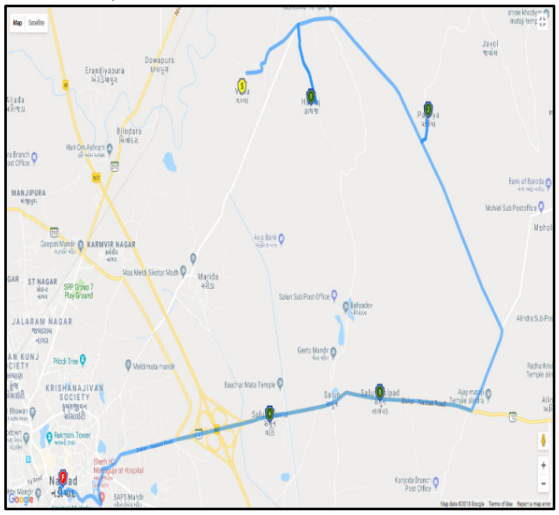
C4R1 : Vina to Nadiad	
Cluster Head	Nadiad
Via	Dawapura, Erandiyapura, Bilodara, Marida, Manjipura, Aljada, Kamla
Total villages covered	8
Route length	26.8 km
Total Waste to be carry	1074.5 Kg/Week

C4R2 Route, Nadiad cluster



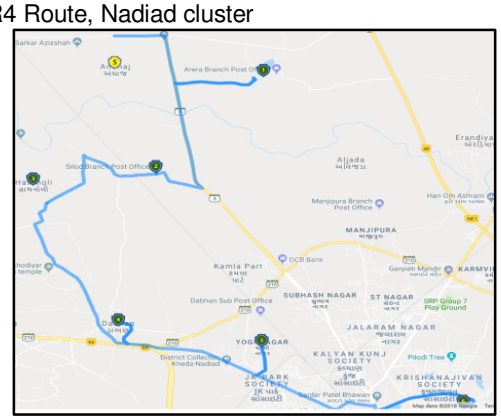
C4R2 : Bhumel to Nadiad	
Cluster Head	Nadiad
Via	Fatepur, Uttarsanda, Gutal, Piplag
Total villages covered	5
Route length	18 km
Total Inert waste to be carry	1250 Kg/Week

C4R3 Route, Nadiad cluster



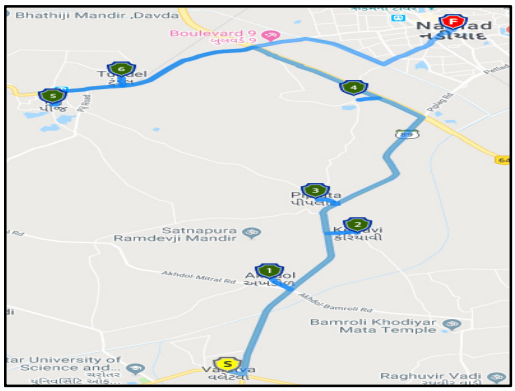
C4R3 : Valla to Nadiad	
Cluster Head	Nadiad
Via	Hathaj, Palaiya, Saluntalpad, SalunVanto
Total villages covered	5
Route length	22 km
Total Inert waste to be carry	1350 Kg/Week

C4R4 Route, Nadiad cluster



C4R4 : Andhaj to Nadiad	
Cluster Head	Nadiad
Via	Arera, Silod, Hathnoli, Dabhan,Yogi nagar, Navagam
Total villages covered	7
Route length	23.8 km
Total Inert Waste to be carry	1225 Kg/Week

C4R5 Route, Nadiad cluster



C4R5 : Valetva to Nadiad	
Cluster Head	Nadiad
Via	Akhdol, Keriavi, Piplata, Dumral, Tundel, Pij
Total villages covered	7
Route length	25.9 km
Total Inert waste to be carry	1900 Kg/Week

B. Cost Analysis for Inert waste solution

We have determined 10 routes that will cover all villages and towns of Nadiad Taluka. All the below clusters &routes are planned according to practical criteria such as, time constraint and capability of the vehicle, total waste to be managed and local on-ground parameters. The waste collection capability of the mini-truck vehicle was rated to be 1.47 tonne. The Table 1 shows the day on which inert waste to be collected for a particular route and also indicates the amount of waste to be collected, on the basis of these trips, the same route was allocated on weekly basis.

Two vehicles are taken into account for the collection of waste from all the routes.

 # indicates the designated day of collection of waste for the particular clusters and routes.

E.g. on Monday a vehicle will go towards for the selected route C1R1 for collection of waste on once per a week.

C Indicates cluster number, R indicates Route number

For the designed routes between the small-scale town and surrounding villages for Integrated Solid Waste Management, it involves various cost to make it successful. It comprises vehicular cost, transportation cost and labor cost. Which are mentioned below.

Table 1: Designed trips in a week for inert waste collection.

Route no.	C1R1	C1R2	C2R1	C2R2	C3	C4R1	C4R2	C4R3	C4R4	C4R5
Waste Quantity (Tonnes)	1.25	2.40	1.22	0.74	1.23	1.07	1.25	1.35	1.22	1.90
Distance (Kilometer)	14.3	23.1	21.1	16.2	38	26.8	18	22	23.8	25.9
Monday	#	#								
Tuesday			#	#						
Wednesday					#					
Thursday						#	#			
Friday								#	#	
Saturday										#

 # indicates the designated day of collection of waste for the particular clusters and routes.

C. Vehicular cost parameters

– Vehicular cost includes the purchase cost of vehicle and maintenance cost of that vehicle.

– The Purchase cost (P) of vehicle for the collection of waste is considered as Rs. 6,25,000 for one vehicle.

– Two vehicles are needed for the collection of waste from all 10 routes.

– Normally the Life of vehicle (L) is considered as a 10 years and Maintenanceis 15%.

– Salvage value (S) is considered as 10% of price of purchase.

– Vehicle cost for 2 vehicles= Rs.12,50,000

– Cost of vehicle per routeV= $\frac{\text{Cost of vehicle}}{\text{No.of Routes}}$

$$V = \frac{12,50,000}{10} = 1,25,000$$

– To compute the depreciation cost per year $D = \frac{P-S}{L}$

(Where D =Depreciation, P = Price of vehicle, S = Salvage of value of vehicle & L = useful Life of vehicle)

$$D = \frac{6,25,000-62,500}{10} = 56,250$$

For two vehicles= 2*56,250 = Rs.1,12,500

Depreciation cost of vehicles per route

$$=\frac{1,12,500}{10}= 11,250$$

– To compute annual maintenance of one vehicle

$$M = \frac{\%\ \text{of maintanace} \times P}{L}$$

(Where= Maintenance cost, P = Price of vehicle & L = life of vehicle)

$$\frac{15\% \times 6,25,000}{10}= 9,375$$

Transportation cost (A):

– It includes fuel need to travel per trip for one route. Generally, a vehicle used for collection of waste gives a mileage of 9 km/lit and most relevant cost of fuel is taken as 70 Rs/lit.

– To compute transportation cost (A) = (fuel need per trip * cost of fuel)

– Fuel need per route

$$= \frac{\text{distance travelled by vehicle per route}}{\text{Mileage of vehicle}}$$

Labor cost (L):

– We have consider 3 labors needed per trip, 1 is driver and 2 helpers.

– Labor cost is taken as 310/day.

– Total cost computed by (X) = Transportation cost (A) + Labor cost (L)

– Annual total cost (C) = Total cost (X) * Annual trips (T)

Investment cost of storage bin & vehicle cost per route (I): Waste Storage bin cost (W)

– Storage bin considers Rs.5000 per piece.

– For 59 villages= 5000*59= 2,95,000

– Per route cost (S) = 2,95,000 /10= 29,500

Vehicle cost (V) = 1,25,000

I = V + W

=1,25,000 + 29,500=1,54,500

Note: The calculations below in Table 2 are considered to be sample estimates. Various costs such as Fuel cost, Transportation cost, Depreciation cost, Labor costs and Vehicle costs are believed to be the most relevant costs and may be subject to changing time to time based on different locations and regarding other factors. The cost of fuel changes daily. Thus the cost of fuel is considered to be Rs.70 as the most common price in specific region which may also be subjected to change.

Table 2: Cost Estimation for Inert waste solution.

Route no.	C1R1	C1R2	C2R1	C2R2	C3
Total waste per Route (Tonnes)	1.25	2.40	1.22	0.74	1.23
Total Kms. per route (2 way)	28.6	46.2*2=92.4	42.2	32.4	76
Fuel need to travel (Litre)	3.17	10.26	4.68	3.6	8.44
A (Transportation cost in Rs.)	222	720	328	252	592
L (Labor cost in Rs.)	930	930	930	930	930
X (A+L in Rs.)	1,152	1,650	1,258	1,182	1,522
T (Trips per year)	48	48*2=96	48	48	48
C(X*T in Rs.)	55,296	1,58,400	60,384	56,736	73,056
D (Depreciation Cost in Rs.)	11,250	22,500	11,250	11,250	11,250
M (Maintenance cost in Rs.)	9,375	9,375*2	9,375	9,375	9,375
C+D+M (in Rs.)	75,921	1,99,650	81,009	77,361	93,681
I (Investment cost (V+W))	1,54,500	1,54,500	1,54,500	1,54,500	1,54,500
Total cost for 1st year (C+D+M+I)	2,30,421	3,54,150	2,35,509	2,31,861	2,48,181
Total Gram Panchayats per route	4	4	6	5	7
Population per route	23,213	37,489	25,454	14,926	25,568
Cost/person for 1st year (Rs.)	9.92	9.44	9.25	15.53	9.70
Cost/person for 2nd year	3.27	5.32	3.18	5.18	3.66

Route no.	C4R1	C4R2	C4R3	C4R4	C4R5
Total waste per Route (Tonnes)	1.07	1.25	1.35	1.22	1.90
Total Kms. per route	53.6	36	44	47.6	103.6
Fuel need to travel (Litre)	5.95	4	4.88	5.28	11.51
A (Transportation cost in Rs.)	417	280	342	370	806
L (Labor cost in Rs.)	930	930	930	930	1860
X (A+L in Rs.)	1,347	1,210	1,272	1,300	2666
T (Trips per year)	48	48	48	48	96
C (X*T in Rs.)	64,656	58,080	61,056	62,400	2,55,936
D (Depreciation Cost in Rs.)	9,375	9,375	9,375	9,375	9,375*2
M (Maintenance cost in Rs.)	11,250	11,250	11,250	11,250	22,500
C+D+M (in Rs.)	85,281	78,705	81,681	83,025	2,97,186
I (Investment cost (V+W))	1,54,500	1,54,500	1,54,500	1,54,500	1,54,500
Total cost for 1st year (C+D+M+I)	2,39,781	2,33,205	2,36,181	2,37,525	4,51,686
Total Gram Panchayats per route	8	5	5	7	7
Population per route	22,836	24,874	24,898	25,480	38,595
Cost/person for 1st year (Rs.)	10.50	9.37	9.50	9.33	11.70
Cost/person for 2nd year	3.73	3.16	3.28	3.25	7.70

The table shows that each person has to pay very little amount yearly.

VII. SOLUTION FOR DECOMPOSABLE AND RECYCLABLE WASTE

From the composition of MSW in villages and small scale towns, it demonstrates that higher amount of generated waste is decomposable. Decomposition and stabilization of organic waste are a natural phenomenon, due to organic nature of wastes, composting is the most suitable, sustainable and environment friendly method of recycling. Compost can be useful to people for farming. We are suggesting some sustainable methods to practice in all villages. By practicing these they can get immediately compost available for their use and it is cheap compared to market artificial compost.

A. Recommendation of Vermicomposting for Decomposable waste

Vermicomposting is a recycling process, where earthworms are allowed to eat organic waste to convert it into manure rich with exceptionally high nutritional content. Vermicomposting is practiced through 'Vermiculture' literally meaning 'to grow worms' or 'worm farming'. Earthworms are cultivated in agricultural farms to consume organic waste including all kinds of biodegradable wastes. They then give out the excreta, which is known as 'vermi-cast'. These vermi-castings are rich in nitrate and contain minerals like phosphorous, potassium, calcium, and magnesium, which are excellent fertilizers and soil conditioners. Through this way produced fertilizers can be directly sell to farmers and which can be an effective source of income.

B. Recommendation for generated Recyclable waste

From the study phase of primary data collection, it was found that about 20-30 percent of total waste is recyclable in the Nadiad Taluka study area. These generated waste can be transferred to recycling industries for further recycling processes through which recyclable waste can be recycled and safe disposal can be achieved. And also which can finally become a strong source of income to manage solid waste management network.

VIII. CONCLUSION

The adoption of the Integrated Solid Waste Management (ISWM) approach through cluster-based waste integration for generated inert waste can be demonstrated as an effective concept for improving the efficiency of SWM in rural and semi-rural areas. The clusters are formed on the basis of distance-based parameters, Total amount of waste to be managed and the local on-site criteria being considered. Cost efficiency is the most important factor in the economic viability of project for which each individual has to pay a very small amount of charge, ranging from Rs. 9-16 for First year and Rs. 3-8 from the second year on. These charges can be reimbursed by selling recyclable waste generated to the recycling industries for further processing, and generated decomposable waste can be used as fertilizer through a vermicomposting process by which it can also be a source of income. This way, inappropriate and unscientific disposal can be avoided. ISWM concept can therefore be recognized as a realistic and advisable technology for Sustainable Solid Waste Management.

REFERENCES

[1]. Jani, J., Pamnani, A., & Shah, J. (2019). Integrated Solid Waste Management for Sustainability: A Review. *International Journal of Engineering Research, 8*(4), 66-69.

[2]. Pamnani, A. (2015). Management of Municipal solid waste: A study of Small scale Municipality. *International Journal of Engineering Sciences & Research Technology*. *4*(1), 19-24.

[3]. Census of India (2011). (www.censusindia2011.com)

[4]. Directorate of Census Operations Gujarat, District Census Handbook Kheda, 2011.

[5]. CPCB (2017). Consolidated Annual Review Report on Implementation of Solid Wastes Management Rules, 2016.

[6]. Joshi, R., & Ahmed, S. (2016). Status and challenges of municipal solid waste management in India: A review.1-18.

[7]. Pamnani, A., & Srinivasarao, M. (2014). Municipal solid waste management in India: A review and some new results. *International Journal of Civil Engineering and Technology, 5*(2), 01-08.

[8]. Pamnani, A., & Meka, S. (2015). Forecasting of Municipal Solid Waste Generation for Small-Scale Towns and Surrounding Villages Located in the State of Gujarat, India. 283-287.

[9]. Central Public Health and Environmental Engineering Organization (CPHEEO), The Manual of Municipal Solid Waste Management by Government of India, 2016.

[10]. Gujarat Social Infrastructure Development Society, Report of Kheda District Human Development Report 2015.

[11]. Directorate of Census Operations Gujarat, District Census Handbook Kheda, 2011.

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