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Sustainable Urban Infrastructure Development for Solid Waste Management of Hamirpur Municipal Area

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Abstract—*This paper focuses on to develop the Sustainable Urban Infrastructure guidelines for Town of Hamirpur for the year 2041 with respect to sustainable solid waste management. The study is based on the field survey of the existing demography and problem associated with existing solid waste management in the study area and the solid waste projection for the year 2041 has been done. A sample survey using questionnaire has been conducted to determine the efficiency of existing solid waste management practices and to know the root cause of inefficiency in the existing system. Further, various successful case studies have been presented and their approaches are suggested for sustainable urban infrastructure development for solid waste management of Hamirpur municipal area.*

1. INTRODUCTION

Sustainable urban infrastructure, is an infrastructure that facilitates a place or regions progress towards the goal of sustainable living. Attention is paid to technological and government policy which enables urban planning for sustainable architecture and initiatives that promote sustainable agriculture [1]. According to the College of Engineering and Applied Science of the University of Colorado Denver [2], urban infrastructure refers to the engineered systems (water, energy, transport, sanitation, information) that make up a city. Challenges resulting from increasing population growth generated a need for sustainable infrastructure that is high performing, cost-effective, resource-efficient and environmentally-friendly. In such a situation efficient utilization of available resources and strategic management of the waste generated should be simultaneously focused on. Sustainable approach should be adopted as a major component of developmental process especially in developing countries like India.

Solid wastes [3] are any discarded or abandoned materials. Solid wastes can be solid, liquid, and semi-solid or containerized gaseous material. Solid waste means any garbage, refuse, sludge from waste water treatment plant, water supply treatment plant, or other discarded materials including solid, liquid, semi-solid, or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations, and from community activities, but does not include solid or dissolved materials in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges. Solid waste management [4], is one of the most prominent aspects of sustainable infrastructure development when it comes to any city. Effective waste management system acts as the backbone any city. Improper handling of enormous waste generated results in a lot of issues like land degradation, pollution, increased carbon footprint and decreased quality of life for the occupants. Littering, open dumping, unscientific ways of landfilling, burning of plastic waste, lack of awareness among the citizens / occupants, improper handling of waste by unskilled workers and lack of technical assistance, machinery as well as funds are the major issues faced in solid waste management.

The study has the following objectives:

1. To identify the status of existing infrastructure facilities regarding Solid Waste Management of the town and to identify the demand of the infrastructure in future.
2. To identify the best sustainable Solid waste management practices across the globe along with its successfulness with respect to its practical feasibility in the area of study.
3. To understand the behavior of the society and their needs regarding solid waste management.
4. To develop suitable guidelines for development of sustainable urban infrastructure regarding efficient solid waste management for the town of Hamirpur by 2041

2. LOCATION OF STUDY AND PRESENT SCENARIO OF SOLID WASTE MANAGEMENT

Hamirpur is a town and is also a district headquarters of the Hamirpur district, located in the state of Himachal Pradesh, India. Hamirpur is located in a relatively warmer region of the western Himachal Pradesh with a lower altitude as compared to the other districts of the state. Hamirpur Town is situated

between 76º 18' to 76 º 44' East Longitudes and 31º 25' to 31º 52'North Latitudes. The town is spread in an area of 5.24 sq. kms. It is well connected by roads from all the districts Headquarter towns of the State as well as neighboring States. Hamirpur town mainly serves as administrative, educational and shopping centre for the surrounding areas.

Hamirpur has sub-tropical climate with average yearly rainfall of about 124.8cms. It is quite hot in summer and cold in winters with occasionally foggy weather. The Temperature varies between 5ºC to 42ºC. Most of the rainfall occurs in July-September. The location of the study area is shown in Figure 1.

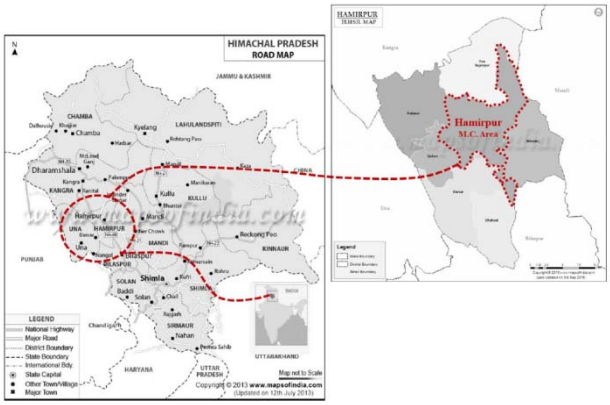

Figure 1. The location of study area

3. METHODOLOGY

The methodology adopted is as under:

1. Analysis of the present scenario of the infrastructure facilities related to SWM practices in Hamirpur town through site visits, interviews, developmental reports, and question answer session with officers of the Municipal council, Hamirpur.
2. Study of various sustainable solid waste management practices worldwide by literature study , review of various journals , site visits etc. and hence identify the best suited 10 practices with respect to the context of area of study and further draw inferences from the case studies itself.
3. Analysis of the societal behavior through survey by interviewing at least 50 people from the Hamirpur municipal area. Further review of the answers and graphical analysis of the needs and limitations.
4. Based on the present scenario , literature studies and survey analysis , draw inferences and propose guidelines for efficient solid waste management for the town of Hamirpur for the year 2041

4. DEMOGRAPHIC STATUS

The Hamirpur Municipal Council has population of 17,604 of which 9,056 are males while 8,548 are females as per report released by Census India 2011 [5]. Hamirpur Municipal Council has total administration over 4,350 houses to which it supplies basic amenities like water and sewerage [6]. It is also authorize to build roads within Municipal Council limits and impose taxes on properties coming under its jurisdiction. As per 2011 census data & Development Report for Hamirpur Municipal Town, 2012 [7], the existing migrant population is 24% of permanent population and hence demographic breakup is shown in Table 1.

Table 1: Existing demographic breakup

Permanent population	Floating / Migrant Population (24% of 17,604)	Tourist population / Day	Total population
17604	4225	5000	26829

As per geometric progression method the permanent population for 2021 will be 20212, 2031 will be 23,200 persons and 2041 will be 26,634 persons (based on the increment rate of population from 1981 to 2011).

5. SOLID WASTE MANAGEMENT

Average per capita solid waste generated is about 0.6 kg/day. Adding to this the solid waste generated by the tourists through hotels, by Industries, Hospitals and Commercial establishments say 50% of town garbage [7] and the total solid waste generated is shown in Table 2.

Table 2: Total solid waste generated

Total Population permanent + migrants	Per capita waste generation / day in Kg	Total waste generated / day in Kg	Total waste generated / day in Kg including tourists and visitors (50% of total waste generated) in Kg	Total waste generated per day + waste generated by tourists per day in Kg
21829	0.6	13097.4	6548.7	19646.1

As per 2011 statistics, annually 71707.9 quintals / 7171790 Kgs of solid waste is generated annually [7]. As per the survey conducted among the scrap dealers in Hamirpur Municipal area, a total of 30 quintals is Total Scrap collected by them per day which makes a total of 10950 quintals per annum. Considering the population projection for 2041 i.e. 26634

permanent residents, the per capita solid waste generation would be 15980 kg /day. It's almost equal to the overall per capita per day waste generation in 2011 (including migrant population and tourists). Presently for the collection of solid waste, Hamirpur Nagar Parishad has identified garbage collection point at different locations near public places, markets etc. and placed portable garbage container. Garbage from these points is cleared almost alternate day and carried to the disposal point. A comprehensive Solid Waste Management Project has been sponsored by the Norway Govt. is being executed by the Municipal Council, Hamirpur at Dugneri village to convert the solid waste into fertilizer in one hand and to prevent the environment from pollution on the other. But the practical implementation and management of the entire solid waste system in Hamirpur town is not up to the mark which is evident from the present substandard conditions around. Present scenario of solid waste management in Hamirpur Municipal Area as identified from the Survey and interaction with local people as well as ground staff working in the solid waste management process for the Hamirpur Town and also from the discussions with officials at Hamirpur Municipal Office revealed the following problems and shown in Figure 2:

1. No segregation at source.
2. Unawareness among the lowest strata of population.
3. Wrongly located garbage bins / unavailability of garbage bins at high density areas.
4. Lack of staff, both in the administration and at the lower levels.
5. Lack of vehicles for the transportation of garbage, equipment and technology for waste segregation and treatment.
6. Lack of funds and governmental policies.

Figure 2: Improper locations of garbage bins

The schemes launched by government for MSWM but did not survived / striving to survive in Hamirpur due to the following reasons:

1. 12 batteries/organic waste to manure conversion units around the town of Hamirpur but none of them are in operating conditions due to unavailability of skilled workers.
2. Lack of techniques for easy segregation of recyclable, non-recyclable and organic waste.
3. Lack of skilled employees to carry out the installed waste treatment plants as they were based on advanced technology.
4. Issues in government policies and implementation of waste management schemes.
5. There is no proper overlooking and implementation of schemes and policies for urban renewal and transformation.
6. Plastic reuse schemes.
7. A policy was launched to reuse plastic in the construction of roads , but that was not effective in the region as the road density was much more and the roads constructed with plastic waste was not able to sustain.
8. Lack of proper waste disposal site/landfill areas: two landfill areas located for the waste disposal of the MSW of Hamirpur town are at the outskirts namely in Dugneri village and Bajuri both more than 15km from the town (Refer Figure 3).
9. Accessibility is an issue. Lack of vehicles for transportation adds to the issue.

Figure 3. Location of landfill sites

Both the landfill locations have solid waste treatment / processing units for the purpose of conversion of organic waste into manure. But it's not functional. Lack of staff at these locations are the reasons for the improper management of disposed garbage which is further causing environmental issues in the vicinity.

6. BEST PRACTICES IN SOLID WASTE MANAGEMENT

ENVIORN , an NGO [8]

Salient features:

1. Community level mass participation and awareness campaigns jointly run by Local Governmental Authorities and ENVIORN.
2. Household level waste segregation and waste composting

3. Use of specially designed Waste Assimilator at household level. Assimilator is designed by President of ENVIRON Dr. Amarjyoti Kashyap. Employment is generated in the making of these bins as well.
4. Generation of micronutrient wash , vermi wash and vermi compost at household level
5. Organic manure can be used for household level kitchen gardens or can be sold off.
6. Organic farming is widely adopted, even in flats. Organic faming is done there in earthen pots.
7. Plastic and other recyclable waste are segregated at household level itself.
8. Specially designed bamboo boxes to store plastic carry bags these bags could be sold to the plastic waste collectors doing door to door collection at community level.
9. As per government strategy , seasonal vegetables are given in exchange of recyclable plastic waste
10. Local garbage collectors and rag pickers are officially involved in this initiative and this plays a vital role in its success
11. ENVIORN with from the funds generated through donations have set up initiatives at community levels by starting small scale industry of making decorative items, artefacts, artificial jewelry etc. from recycled plastic
12. Since 2003, joint efforts from government and ENVIORN has helped to reduce the waste going to the landfill sites by 60%.

Considering the location i.e. Eco sensitive, hilly areas and also considering crowd typology, this / similar solutions are the most appropriate ones for Hamirpur city. Such indigenous, local and economic approach can give positive results in the context of Hamirpur as well.

7. WASTE TO ENERGY STRATEGIES IN SWEDEN [9]

Salient features:

1. Segregation at source widely practiced
2. PPP in solid waste management , community participation involved
3. Incineration plants from waste to energy conversion
4. Electricity is produced on this principle
5. Technically sound and trained employees working in Solid Waste Management and Treatment centers
6. Sweden in 2015 has imported waste from nearby areas to the production of electricity by this means
7. Less than 2% of waste goes to the landfill annually
8. Efficient laws regarding waste management and disposal
9. Strict rules on recycling of electronics and management

Though it has 100% success rate in Developed countries like Sweden, unavailability of funds and lack of technically sound workforce can cause this approach to not be successful in a developing country like India. And Hamirpur is not even a metro city in India, so its feasibility is really low here.

In case of a developing countries like India , especially for a small urban settlement like that of Hamirpur , local , indigenous and native methodologies are best suited , where minimum capital investment and maximum benefits are there. Moreover, the technique should be so that it could be easily understood and handled by the lowest strata of society, as the study area has unskilled employees working mostly in this sector. Micro level as in household level or community level solid waste management would be more appropriate and convenient to handle and focus on in such a scenario.

8. LAGOS , NIGERIA - PPP AS A SOLUTION TO WASTE MANAGEMENT

Salient features:

1. Population growth is the biggest issue corresponding to it is the issue of waste generation
2. Netherland funded waste management project
3. Legalizing scavenging and setting fixed rates for recyclable products
4. Collected recyclables could be sold at PPP run recycling centers at fixed costs.
5. Improved door-to-door waste collection , improved numbers of waste collection and transportation machines, equipment’s and staff
6. Financial incentives given to communities and individuals who participated in waste management programs.
7. Poor and unmanaged dumping of waste at landfill sites

Legalizing Scavenging and improvement of door -to -door collection is an apt. and necessary step in the context of Hamirpur town

9. SURVEY AND ANALYSIS

A door to door survey was conducted with a target size of 50 people living in and around the municipal area of Hamirpur to understand the behavioral pattern and response of the people who are actually directly linked with the issues and are in fact most affected by as well. Out of the proposed 50, only 43 surveys could be completed as many people were unwilling to answer / spare time. Target Area was commercial and residential area in and around Hamirpur Municipal area. The

questionnaire carried 16 questions regarding the present scenario of solid waste management in the Hamirpur Municipal Area. It further tried to identify the major problem which the people are facing due to the improper management in the MSWM system. The questionnaire also tried to find out the willingness of the people on incorporation of certain efficient solid waste management strategies and their acceptance about for the proposed methodologies.

Out of 16 questions 11 were direct questions which had to be answered in yes or no (Absolute method) out of the rest 5, 2 questions were interlinked questions with scale rating and rest three were direct questions which had to be answered from the given 5 options (Range).

The findings of the survey results are discussed below:

1. As per the survey analysis door to door garbage collection is not effectively implemented, almost 70% of people surveyed denied the facility.
2. Commercial areas a covered under the door –to door garbage collection system up to 65% as per the survey. 83 % of the people surveyed are not paying any fee to the authority for garbage collection and management at present.
3. Almost 80% people surveyed are willing to pay a nominal fee for the waste collection and management activities, provided proper implementation of the same.
4. Almost 68% of people surveyed are willing to indulge in segregation at source practices on government initiatives.
5. 87% of people surveyed have denied of any solid waste management practices at household or community level.
6. 59% of surveyed people are willing to adopt organic farming at household levels under supervision and consultation as well as incentive facilities from government.
7. More than 63% of the people surveys showed no interest in directly getting involved in recycling industrial activities and craft centers for part time employment.
8. Out of the 14 people, whose houses are covered under door – to –door garbage collection only 28% people admitted a garbage collection on daily basis while 35% people admitted the weekly garbage collection is done.
9. Out of the 27 people, whose shops are covered under door–to-door garbage collection, only 14% people ensured garbage collection on daily basis, 33% people admitted the collection being happening on weekly basis while 44% agreed the garbage collection to happen within every 3-4 days.
10. Out of the 43 people who were surveyed, 52% people rated the performance of the municipal authority to be average in managing solid waste, while only 0.6% people rated it to be very good.
11. Out of the 43 people who were surveyed , 13% were not willing to pay any fee for solid waste management , while rest were willing to pay nominal amount as decided by the government (50-75 Rs being the most favorable range).
12. As per the responses from the 43 people who were surveyed, 68% people mentioned open dumping to be the most common Solid waste management problem, followed by improper location of garbage collection bins (23%) and less number of staff (0.6%).

10. CONCLUSION

Based on the observations of present scenario of solid waste management in Hamirpur Town , the analysis of sustainable solid waste management practices adopted worldwide and the analysis of the survey results have led to following inferences:

1. Most common problem in the present SWM system is minimum initiatives from the government's side, there are no proper awareness programs or campaigns, which should have been there considering the rapid population growth, continued migration and growing tourists / visitors. There are no periodic surveys which are being conducted to keep a close watch on the growth trends and changes in that
2. Inclusive approach of solid waste management involving users as well as the localities are not there.
3. Lack of coordination between the government authority and the contract bearers who are responsible for the ground level collection, management and disposal of solid waste.
4. The present scenario of solid waste management process has a very weak base. There is no proper door to door garbage collection, improper location of community bins, delayed waste pickups, no segregation and recycling of possible waste products, no scientific landfilling.
5. Being in an eco-sensitive region solid waste management should have been of immense importance to the people of the lace a well as the authorities in charge, which is missing here.
6. People are willing to adopt segregation at source, if government introduces certain schemes and incentives for its promotion. The survey results clearly sates the peoples willingness to adopt sustainable methods of solid waste management like composting at household level , organic farming , segregation based on the typology of waste at household level itself , if government offers them fiscal benefits and other tokens of appreciation.
7. Indigenous solutions clubbed with tailor-made strategies for the town can help mitigate the solid waste management issues in the years ahead. As per the population projection for 2041 and subsequent solid waste management generation , by 2041 , the per capita solid

waste generation of the permanent residents of Hamirpur municipal area is going to be 15980Kg/day (for a population of 26634)which is almost equivalent to the total solid waste generated by the permanent residents , migrants and tourists altogether.

The population projection for the 2041 as per geometric progression method is 26634 persons which is just the count of permanent residents for the town. apart from this 24-30% of migrant populations and 5000-6000 per day average tourist population would club up to 40,600 people and according solid waste generation per day would sum up to 24,360kg which would again sum up to 88,91.400 kg annually, which is an enormous amount for a fragile and eco sensitive region like Hamirpur , which falls in the foot hill region of Himachal Pradesh. In such an alarming situation all should strictly abide by certain guidelines and firmly stick to it ensuring the ecological balance of the place is not disturbed. An efficient solid waste management system is the backbone of an economically stable and sustainable city. The following specific recommendations have been given:

A. Inclusive solid waste management, local solutions – involving local people

The study of ENVIORN revealed that considering the limitations of a geographically sensitive city and being a part of a developing country like India, Hamirpur town should adopt an indigenous way of Municipal Solid waste management System. Involving local people and adopting local practices like NADEB Composting, Conventional vermin composting etc. at community level would generate employment opportunity at local level. Generating awareness among all sections of society and working together at every level from house hold segregation , to increased door to door collection to waste transportation to further segregation and disposal should have an open and aware approach of the right ways to do it and the duties of every individual should correctly do his part and the government should come up with schemes and incentives to appreciate the contribution of the citizens and the workforce for their efforts time to time. Legalizing scavenging and such activities and incorporating them in the strategy of solid waste management would make a lot of difference in the efficiency of the process. Those whose are directly linked with it should be prioritized the most.

B. Public Private Partnership Initiatives should be developed to ensure the availability of funds, supervision and funds for the efficient functioning of SWM practices.

The study of Sweden revealed that one of the most prominent loop hole in inefficient management of Solid waste is unavailability of work force and unskilled labor. In such a case government should team up with privatized organizations and hence tackle this issue ensuring proper work force, funds and supervision.

C. Scientific landfilling is a must practice and should be followed for better long term result.

The study of Nigeria revealed that scientific landfilling ensures, minimum harmful waste goes into the landfill site after proper analysis and the landfill in so designed to counter possible pollution effects, ground water quality, on site composting, on site segregation for recyclable objects including e-waste. The site can also be used to generate more economy and employment by adding on Plan nursery beehives, fruits bearing trees, small scale vegetable garden etc. which would add to the plus points of the approached provide better quality of life to the lower strata of society.

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