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PROJECTIONS FOR THE POPULATION GROWTH AND ITS IMPACT ON SOLID WASTE GENERATION OF A MEDIUM SIZED NORTH INDIAN CITY

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***Abstract*— The basis for population growth and policy option scenario is the variation in birth, death and migration rates. Population of Sonipat city is projected to stabilize around a value of 397,425 by 2035 for a policy option scenario proposed to achieve this target. Recycling and composting of solid waste are considered to estimate the quantity of the waste remaining to be dumped at landfill site. Segregation of recyclable fraction and composting of biodegradable part of the solid waste should be essential to manage the waste of medium-sized cities.**

***Index Terms*— Population, policy option scenario, system dynamic, solid waste**

I. INTRODUCTION

The growing population in the developing countries is of social, political and economic concern. It has direct impact on available resources and contributes to the waste generation. People migrate to towns and cities in search of jobs and to seek better amenities. It is estimated that in India about 100,000 people move daily from rural areas to urban areas[1], making annual migration to the tune of about 3.6 per cent of the population. This is not a desirable trend as the infrastructure and other resources of the cities and towns get further constrained to accommodate this migration. The municipal authorities have to face the issues to manage the growing amount of solid waste resulting from the population growth.

The population growth rate, however, decreased to 1.17% in 2008 from 2.11% in 1970 [2]. The decrease in population growth was due to global decline in fertility and increase in mortality in some regions, for instance HIV related increase in mortality in some parts of Africa. In 2009, the world population was estimated to reach 6.8 billion. In the list of countries ranked by population, People's Republic of China tops the list with nearly 19.5% of the World population followed by India (17.3%), United States (4.5%), Indonesia (3.4%) and others. India's population reached one billion on 11th May 2000.

In developing countries population is distributed in metropolitan cities, towns and villages. It is estimated that about 24% of the Indian population lives in urban areas and the remaining 76% is the rural population. Overall population density in the country, which is higher than that of any other nation of comparable size, has risen from 216 persons per square kilometer in 1981 to 324 by 2001[3,4]. The growing population leads to increase in the amount of solid waste, and this increase poses serious threats to the environment including the underground water [5,6]. The solid waste contains various biodegradable and non-degradable materials [7,8]. Segregation and composting of biodegradable components of the solid waste are regarded as environmentally benign options [9].

Methods and solutions to address the issue of population growth and its impact on the solid waste of a medium-sized city are of interest to the policy planners and decision makers [10, 11]. Scenarios for waste management need to be developed to cope with its growth. Innovative methods of solid waste handling and disposal are becoming increasingly popular to reduce the amount of waste. John [12] has studied sustainability based decision support system for the solid waste management.

In this paper, we investigated the population growth of a city to develop policy options scenarios to arrive at population stabilization option. A system dynamic approach is used and the birth, death and migration rates are taken as controlling factors. Investigations were made for the medium-sized city of Sonipat. This is the district headquarter city of the North Indian state, Haryana. Impact of the population growth of the city on the solid waste generation is studied to give projections for managing the solid waste corresponding to policy option scenarios.

II. METHODOLOGY

A system dynamic (SD) approach is used to estimate the population growth and solid waste generation for baseline and modified scenarios. It has been applied to study the growth of municipal solid waste and to suggest policy options applicable to solid waste management [13,14,15]. We have used Powersim constructor version 2.51 to run the model on a computer. Policy option scenario is developed to make

projections till 2035. A stock flow diagram, shown in Fig. 1, is used to develop SD model for the present investigations. The diagram shows how the interrelated variables are affected one another. Computer simulations of the dynamical system, which are essentially time dependent [16,17] are performed using the policy parameters.

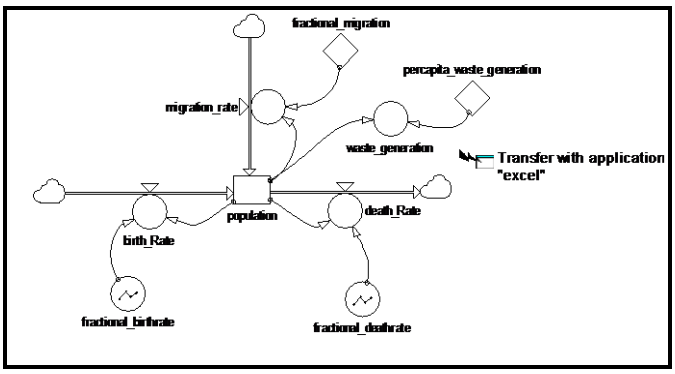

Fig. 1 The stock flow diagram of the model developed for studying the population growth and associated solid waste generation.

A. *Place*

The medium-sized city of Sonipat is in close proximity to New Delhi, the capital city of India. Geographically, it is located between 28°48'30" and 29°17'54" North and 76°28'30" and 77°13'40" East. Its terrain is just flat and agriculture is the main profession of people living in the surrounding villages. As mentioned earlier, it is the headquarter city of a district of Haryana state. Currently spread over approximately 30 sq. km., Sonipat is a rapidly expanding city.

Table 1. Input parameters for the baseline scenario[1]

Population in 2001	Rates per thousand
225 074	Birth : 26 Death : 6 Migration : 5

[1] CDPR (2005) *City Development Plan Report for Sonipat*

III. MANAGEMENT OF WASTE IN MEDIUM-SIZED CITIES

Rapid growth of population poses major challenge to the ecological balance and is of environmental concern. We, therefore, studied the impact of population growth on the municipal solid waste generation of Sonipat city for the policy scenario. Solid waste in medium-sized cities is generated in residential, commercial and industrial areas. Educational institutions, hospitals and sweeping of roads and streets add to the total waste generation. Bins or sites for dumping the solid waste are located at different places on the side of roads where the collected waste is dumped. Unlike in some western countries, the solid waste is collected on daily basis from individual families or institutions. Generally, the solid waste, other than papers, is not segregated at the sources of generation.

Municipal authorities are responsible for managing the solid waste of cities [18,19]. In most of the medium sized cities, the solid waste is simply dumped at some low lying areas on the outskirts and left to degrade with time causing environmental pollution. Facilities for processing of biodegradable materials do not exist. The solid waste generated in cities mainly consists of paper, plastics, metals, glass, textiles, leather, ash, dust and food. Industrial and hospital waste is generally collected and processed separately. There is strong correlation between solid waste composition and socioeconomic factors [20]. An average composition of the solid waste is usually considered to study options for processing and disposal of the waste at the landfill sites. We required an estimate of the recyclable and biodegradable fractions in the solid waste of Sonipat to formulate policy option scenarios. This was estimated from the average composition given by [21, 22] for Indian cities.

The need for regulating the population growth through diverse birth control measures is felt all over the world. As an example, for making it explicit and to clearly reflect the seriousness of the problem due to unplanned growth of population, we also studied the impact of population growth on solid waste generation. Talyan et al. (2008) [23] have studied the municipal solid waste management for Delhi, the capital of India, to cope with the growth of the waste.

IV. RESULTS AND DISCUSSION

In India, multipronged efforts are made for controlling the population growth. To provide overall guidance to achieve rapid progress for population stabilization and have sustainable development, the Government of India has constituted National Commission on Population (NCP, 2000). The Department of Family Welfare of the government has formulated National Population Policy (NPP) 2000 with long term objective of achieving stable population. The medium-term objective was set to bring the Total Fertility Rate (TFR), defined as the average number of children each women would have in her life time, to replacement levels by 2010. On national level, the crude birth rate, infant mortality rate and TFR were projected as 23, 50 and 2.6 for 2002 and 21, 30 and 2.1 for 2010 respectively to meet the NPP objectives. Migration rate also plays an important role for projecting the population of a region or a city.

Sonipat is located in more developed region of the country and hence here the national policy measures are implemented at accelerated pace in comparison to the under-developed

regions. We, therefore, set a target to achieve population stabilization by 2035, which is ahead of the nationwide target of 2045. The SD model is used to make projections for the births, deaths, migrations and the overall population trends over a 35-year span from 2001-2035 under policy option scenarios. The total population of Sonipat in 2001 was 225,074. From 1991-2001, the decennial population growth rate was 56.4% [4]. Annual birth, death and migration rates per one thousand of population were 26, 6 and 5 respectively. In this study, policy scenario (PS1) is considered. This scenario showed the impact of parametric variations on the population growth.

Policy Scenario(PS1) : This scenario is formulated to work out a policy option to stabilize the population of Sonipat by 2035. In this scenario, the annual birth, death and migration rates per one thousand are taken 26, 6 and 5 respectively from 2001 to 2006. After 2006, the annual decrease in the deaths and migrations of 0.1 and 0.15 per thousand are considered. From 2007 to 2020 the birth rate per thousand is considered to decrease by 0.5 every year and from 2021 to 2035 it is annually decreased by 1 per thousand. The annual decrease in stages is considered to arrive at a policy to reach steady state of population growth. This should be achievable as the city of Sonipat is located in the developed region of the country and here the literacy rate is high. The result of this scenario is shown in Fig. 2. It is evident from the figure that the population of Sonipat can be stabilized at a value around 397,425 if the proposed drastic steps are taken to have substantial reduction in the birth rates.

The per capita waste generation of 0.324 kg/day was considered [24]. Per capita waste generated per day in Delhi is 0.5 kg [25] and it is 0.450 kg in Mumbai [26]. The municipal authorities manage the solid waste generated in the city; the waste is collected from the roadside bins, transported and simply dumped at low lying open field dumping site. Recycling and composting of the solid waste is essential and should be an integral part of waste management practice [19]. But in medium-sized cities there are usually no organized facilities for composting or recycling the waste. Rag pickers, however, scavenge a fraction of the waste from the bins and dumping sites.

We considered composting of the biodegradable waste to make projections for the quantity of disposable waste remaining to be dumped. Like in other medium-sized cities of the developing countries, the solid waste of Sonipat contains approximately 50% biodegradable fraction. We, therefore, analyzed two scenarios considering 20% and 50% composting of the waste to study their impact on the waste management policy. It is desirable to compost most of the biodegradable fraction of the waste. Our study gives policy guidelines, but techno-economic feasibility should be considered to make a specific choice of composting fraction. It is expected that affordable and viable technology will become available in due course of time.

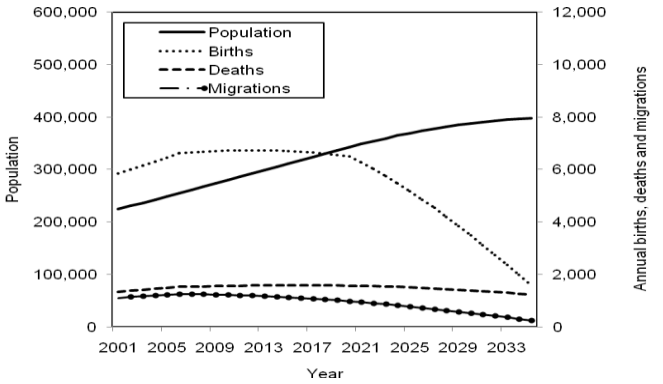

Fig. 2 Projections of births, deaths, migrations and total population of Sonipat for the policy option scenario.

In Sonipat city, the recyclable fraction of waste ranges from 9% to 15% [24]. In the light of uncertainty we used the value of 9% recyclable fraction for the year 2001, which was expected to rise to 26% by the year 2035. The recyclable fraction was considered to be removed by the rag pickers and sorting at the generation points prior to collection of the solid waste. This is presently practiced in Sonipat and other towns. Though technological advancements will take place, this practice, which is a source of livelihood for the rag pickers and also for those involved further down the line, will continue in the years to come. The activity of recycling the waste material sorted from the solid waste is well organized by the people involved in it.

Figure 3 shows the temporal projection of the collected solid waste, recycled waste and the waste remaining to be dumped at landfill site for the policy option scenario of population growth. Recycling of the waste by rag pickers was increased from 9% to 26% from 2001 to 2035. The solid waste collection efficiency was taken as 80% of the total waste generated. Scenarios for 20% and 50% composting of the solid waste were anlayzed. Quantity of the waste remaining for final disposal at landfill site is also shown in Fig. 3 for 20% and 50% composting of the collected waste.

The area of landfill required for dumping the waste can be evaluated by assuming the solid waste density of 0.85 tons/m^3 and 10 m height/depth of filling, half below and half above the ground. It is evident from Fig. 3 that in 2035 approximately 13,910 tons solid waste of Sonipat will remain after segregation and composting for the fourth policy option scenario. Its disposal will, therefore, need an area of 2,006 m^2 with 10 m height/depth of filling. In the master plan of a city, a landfill site is usually planned to accommodate the waste for 20 years. An additional 30 m space is required around the landfill site to place equipments and a 500 m wide buffer zone of no development is maintained surronding the site.

These projections should prove to be useful for the policy planners and the municipal authorities to develop infrastructure for sustainable development of the city. Control of the population growth shall have direct bearing on the the waste generation and to have sustainable development plans of

solid waste management. Multi-criterion approach of segregation of the recyclable materials and composting of the biodegradable fraction [12,19] will be in line with the government of India policy of the solid waste management planning for medium-sized cities.

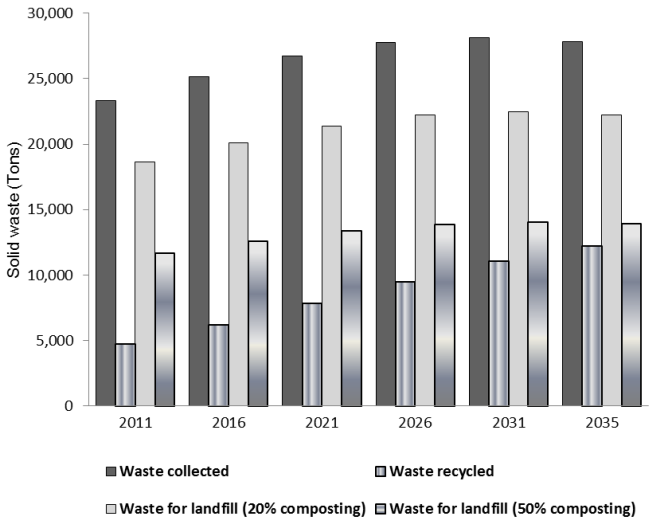

Fig. 3 Temporal projection of the collected solid waste (with 80% collection efficiency), recycled waste and the waste remaining to be dumped at landfill site (after 20% and 50% composting) for the policy option scenario of population growth.

V. CONCLUSIONS

The system dynamic approach was used to project population growth and its impact on the solid waste generation of a district headquarter city Sonipat. Its 2001 census value of 225,074 is predicted to reach 521,118 by 2035 for the as usual, the baseline scenario. Birth rate, death rate and migration rate were varied to generate policy option scenarios. The growth of solid waste can approach steady state by 2035 if the annual birth rate is reduced in stages, as given in the policy scenario. This study of the population growth and solid waste management will be useful for medium-sized cities located in plane areas of the country. Removal of recyclable fraction and composting of biodegradable components should be an integral part of the waste management policy to handle the increase of the solid waste with population growth. These measures will decrease the quantity of solid waste remaining for final disposal at landfill site. The policy measures with multi-pronged approach of population control, and recycling and composting of solid waste will make significant impact on sustainable development of the region.

REFERENCES

[1] Dhongde, S. 'Measuring the impact of growth and income distribution on poverty in India', *Journal of Income Distribution*, Vol. 16, No. 2, pp.25–48, 2007.

[2] World Bank (2010) *World Development Indicators*, Accessed on July 2010, http://data.worldbank.org/data-catalog/world-development-indicators.

[3] Census (1991) *India Census Reports of 1999*, Ministry of Home Affairs, Government of India, http://censusindia.gov.in.

[4] Census (2001) *Census-2001 Data Online*, Ministry of Home Affairs, Government of India, http://censusindia.gov.in/2011-common/censusdataonline.html.

[5] MoEF, (2000) *Municipal Solid Waste (Management and Handling) Rules, Ministry of Environment and Forests*, Government of India, New Delhi, India.

[6] Mor, S., Ravindra, K., Dahiya, R.P. and Chandra, A. (2006 b) 'Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site,' *Environmental monitoring and assessment*, Vol. 118, Nos. 1-3, pp. 435-456.

[7] Lauber, J.D. (2005) *The burning issues of municipal solid waste disposal – what works and what doesn't,* Toronto City Council Municipal Solid Waste Conference: Advances in Processes and Programmes.

[8] El-Salam, M.M.A. (2010) 'Hospital waste management in El-Beheira Governorate, Egypt', *Journal of Environmental Management*, Vol. 91, pp. 618-629.

[9] Lavagnolo, M.C. (2010) 'A glance at the world', *Waste Management*, Vol. 30, pp. 162-164.

[10] Chen, H.W. and Chang, N.B. (2000) 'Prediction analysis of solid waste generation based on grey fuzzy dynamic modelling', *Resources, Conservation and Recycling*. Vol. 29, pp. 1-18.

[11] Srivastava, A.K. and Nema, A.K. (2008) 'Forecasting of solid waste composition using fuzzy regression approach: a case of Delhi', *International Journal of Environment and Waste Management*, Vol. 2, No. (1/2), pp. 65-74.

[12] John, S. (2010) 'Sustainability-based decision-support system for solid waste management', *Int. J. of Environment and Waste Management*, Vol. 6, Nos. 1-2, pp. 41-50.

[13] Anand, S., Dahiya, R.P., Talyan, V. and Vrat, P. (2005). 'Investigations of methane emissions from rice cultivation in Indian context', *Environment International*, Vol. 31, No. 1, pp. 469–482.

[14] Dyson, B. and Chang, N.B. (2004) 'Forecasting of solid waste generation in an urban region by system dynamics modeling', *Waste Management*, Vol. 25, No. 7, pp. 669–79.

[15] Karavezyris, V., Timpe, K. and Marzi, R. (2002) 'Application of system dynamics and fuzzy logic to forecasting of municipal solid waste', *Math. Comput. Simul*, Vol. 60**,** pp. 149–58.

[16] Forrester, J. W. (1971) *World Dynamics*, Wright–Allen Press, Cambridge, USA.

[17] Mohapatra, P.K.J., Mandal, P. and Bora, M.C. (1994) *Introduction to system dynamics modeling*, Orient Longman Ltd., Hyderabad, India.

[18] Saxena, S., Srivastava, R.K. and Samaddar, A.B. (2010) 'Towards sustainable municipal solid waste management in Allahabad City', *Management of Environmental Quality: An International Journal*, Vol. 21, No. 3, pp. 308-323.

[19] Uiterkamp, B.J.S., Azadi, H. and Ho, P (2011) 'Sustainable recycling model: A comparative analysis between India and Tanzania', *Resources, Conservation and Recycling*, Vol. 55, pp. 344–355.

[20] Burnley, S.J., Ellis, J.C., Flowerdew, R., Poll, A.J. and Prosser, H. (2007) 'Assessing the composition of municipal solid waste in Wales', *Resources, Conservation and Recycling*, Vol. 49, pp.264–283.

[21] Gupta, S., Mohan, K., Prasad R.K., Gupta S. and Kansal, A. (1998) 'Solid waste management in India: options and opportunities', *Resources, Conservation and Recycling*, Vol. 24, pp.137–154.
[22] Zurbrugi, C. (2002) 'Urban solid waste management in low-income countries of Asia how to cope with the garbage crisis', *Scientific Committee on Problems of the Environment (SCOPE),Urban Solid Waste Management Review Session*, Durban, South Africa.
[23] Talyan, V., Dahiya, R.P. and Sreekrishnan, T.R. (2008) 'State of municipal solid waste management in Delhi, the capital of India', *Waste Management*, Vol. 28, pp. 1276-87.
[24] CDPR (2005) *City Development Plan Report for Sonipat*, Design and Development Forum for the Haryana Urban Infrastructure Development Board, Sonipat, India.
[25] NEERI (2005) *Executive summary for status of MSW management in 59 cities of India*, National Environmental Engineering Research Institute, Nagpur, India, http://neeri.res.in/swm.html.
[26] Angelene, G.J.R. (2010) 'A critical analysis of existing municipal solid waste management practices in Madurai city', *Transactions of the Institute of Indian Geographers*, Vol. 32, No. 1, pp. 27-40.