System Dynamics Using Stella
A Case Study of Population Dynamics in City of Surabaya

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ABSTRACT

The projection of millennium development goals (MDGs) indicators is important to evaluate the achievement of those goals. Evaluation can be done yearly until 2015 so that any correction of the programs that provide the achievement of MDGs can be done properly. City of Surabaya by mean of IIHD and AUICK has accomplished such projection. Secondary data analysis by mean of Stella Software was used to make the projection of population size, three of eight indicators of MDGs such as proportion of people living on less than US$ 1 per day, proportion of students reaching grade 5, and child mortality up to 2015. The results showed that first, based on medium, high and low range projection, by 2015 population size will be respectively 2,757,620; 2,947,249 and 2,844,467. Second, based on medium, high and low range projection, by 2015 the proportion of people who live on less than US$1 per day will be respectively 68.26%, 74.25% and 65.41%. Third, based on medium, high and low range projection, by 20 5 the proportion of students who start grade 1 and reach grade 5 will be respectively 24%, 36% and 18%. Fourth,, based on medium, high and low range projection, by 2015 infant mortality rate will be respectively 31.11, 30.42, and 31.48 per 1,000 live births. While under five child death will be respectively 37.16, 36.33 and 37.60. It is recommended to the government of City of Surabaya in achieving three of eight MDGs mentioned above to consider to the results of projections of proportion of people living on less than US1 per day, proportion of students reaching grade 5, infant and under five child mortality rate by selecting the scenario.

Key words: *stella, population dynamics*

INTRODUCTION

Over years people who concern with population estimates and projections use various methods such as linear interpolation, polynomials, geometric, logistic, and component methods (Pollard, 1974). Since the last two decades, the rapid development of computer hardware technologies as well as the computer softwares results in various statistical packages such as SPSS, SAS, MINITAB etc. In the area of population study particularly for population projection, A Stellla software is a choice. It is easy to use and to interprete.

Globally, now people deal with millenium development goals (MDGs). The leaders of the countries of the UN members have agreed to achieve eight MDGs in the year of 2015. The performance has begun in 2000 and the evaluation will be done in 2015. For example, the governments of those countries are doing the programs which range from halving extreme poverty to halting the spread of HIV/AIDS and providing universal primary education, all by the target date of 2015 – form a blueprint agreed to by all the world's countries and all the world's leading development institutions. They have galvanized unprecedented efforts to meet the needs of the world's poorest (UNDP, 2008).

City of Surabaya, is the second largest city in Indonesia. As member of city association coordinated by AUICK (Asian Urban and Information Center of Kobe), it participates in study of assessment of MDGs. This paper is the part of the study organized by IIHD that have been completed in 2005.

METHOD

The secondary data were obtained from the study sponsored by AUICK as part of an international project with UNFPA assistance done by Indonesian Institute of Human Development (IIHD) and *Dana Sejahtera Mandiri* Foundation cooperation with Central Board of Statistics, City of Surabaya as the member of research team organized by Indonesian Institute for Human Development (IIHD). The data were collected by Indonesian Statistical Foundation (Instat) and Central Board of Statistics City of Surabaya.

The data were analyzed by mean of Stella software. Only the data of population size and those that represented three of eight indicators of MDGs to be analyzed such as proportion of people living on less than US$1 per day, net

enrollment ratio in primary school, under five mortality rate and infant mortality rate.

The Stella diagram is easy to perform. It includes one stock that represents the population size in the given population under study at any given point in time. It also includes one inflow that represents the number of people that flow in per given time from the source. These two parts are connected with increase rate that makes the population size in the stock greater than that before.

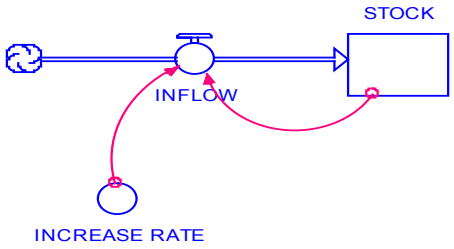

Figure 1. Inflow Diagram

The population size may decrease for some reasons. Hence, the diagram includes one outflow that represents the number of people that flow out per given time from the stock. These two parts are connected with decrease rate that makes the population size in the stock smaller than that before.

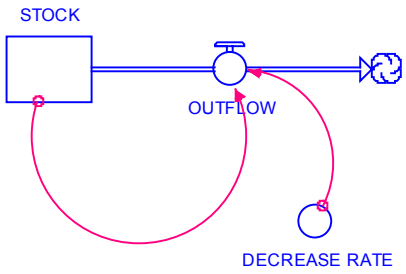

Figure 2. Outflow Diagram

The following diagram shows the dynamics of population growth that is influenced by two indicators, birth and deaths ignoring in-migration and out-migration.

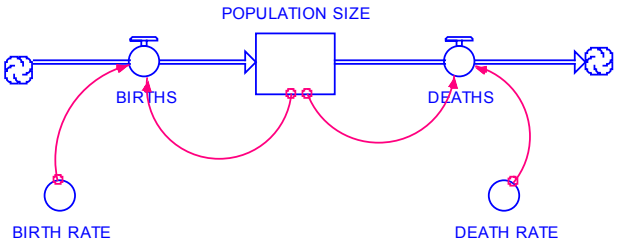

Figure 3. Population Dyanmics Diagram

Projection was made from 1990 to 2015 when the initial data in 1990 was available, otherwise the initial data were used was according the available data. There are three scenarios for projecting the MDG's indicators, first, Medium Range Scenario in which the number or proportion or rate in 2015 will reduce by 50% of the initial number or proportion or rate. Second, High Range Scenario in which the number or proportion or rate in 2015 will be 50% higher than that Medium Range Scenario in 2015. Third, Low Range Scenario in which the number or proportion or rate in 2015 will be 25% lower than that Medium Range Scenario in 2015.

RESULTS AND DISCUSSION

Population Size

The population of City of Surabaya according to the 1990 and 2000 population census were respectively 2,473,272 and 2,599,796 (BPS, 2005). The following graphs and table show the population dynamics based on medium, high, and low range scenario. In those scenarios the population components such as CBR and CDR tend to decrease, while the population size tend to increase. Overall, in 2015 based on three scenarios the population size will not exceed 3 millions.

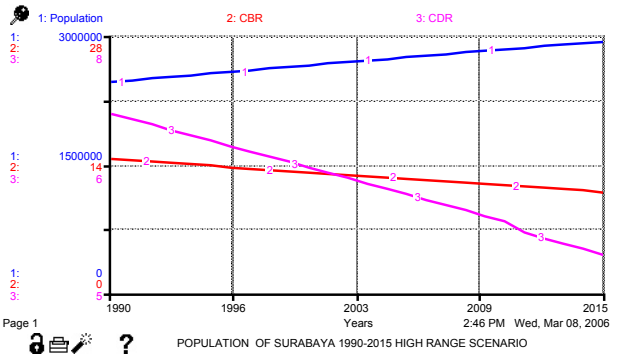

Figure 4. The Trend of Population Size, CBR, and CDR in City of Surabaya 1990–2015. Based on High Range Scenario

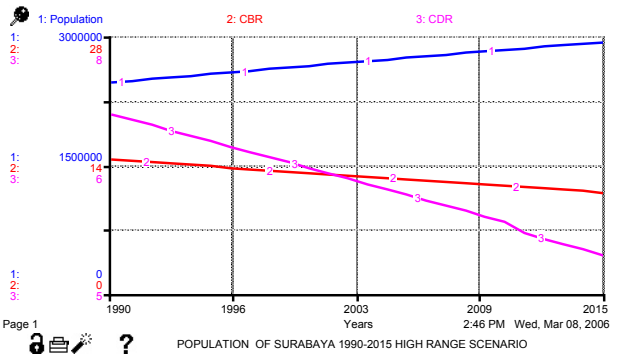

Figure 5. The Trend of Population Size, CBR, and CDR in City of Surabaya 1990–2015. Based on High Range Scenario

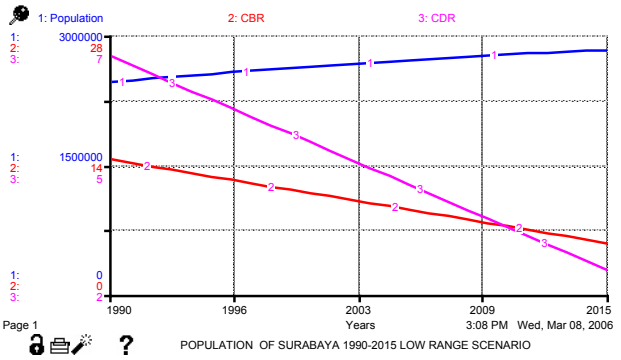

Figure 6. The Trend of Population Size, CBR, and CDR in City of Surabaya 1990–2015. Based on Low Range Scenario

Based on the asumption, the population size in the beginning of projection was 2,473,272 as reported by population census in 1990. In 1990 CBR was 14.55 per 1000 births, and CDR was 6.6 per 1000 births, in-migration and out-migration was assumed to be zero (Made Ari Brata, 2006, personal communication). Based on Medium Range Scenario in 2015 CBR and CDR will decrease 50% to be respectively 7.28 per 1000 births and 3.3 per 1000 births. Hence, in 2015 the population size will be 2,757,620. Based on High Range Scenario in 2015 CBR and CDR will be 50% higher than 7.28 and 3.3 respectively. Hence, in 2015 the population size will be 2,947,249. Moreover, based on Low Range Scenario in 2015 CBR and CDR will be 25% lower than 7.28 and 3.3 respectively. Hence, in 2015 the population size will be 2,844,467.

People Living on Less than US$1 per Day

One of the eight MDGs that will be achieved in 2015 is eradicating extreme poverty and hunger particularly for people who live with only less than 1 US$ per day. The following figures and tables show the trend of proportion of people live with only less than 1 US$ per day.

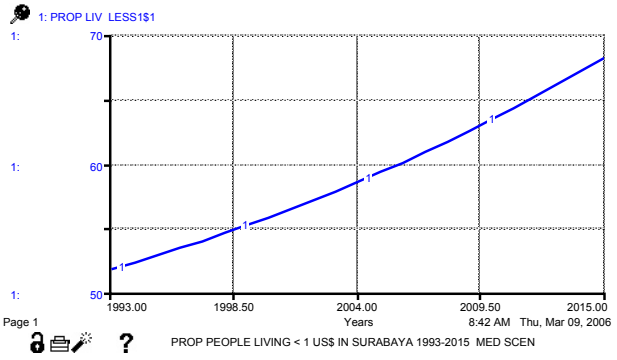

Figure 7. Trend of Proportion of People Who Live Less Than 1 US$/day. Based on Medium Range Scenario

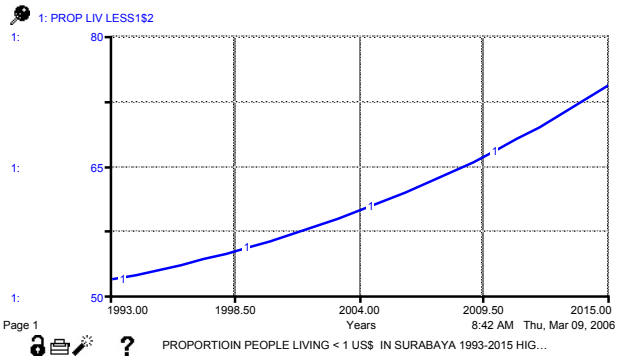

Figure 8. Trend of Proportion of People Who Live Less Than 1 US$/day. Based on High Range Scenario

Table 1. Population Projection in City of Surabaya 1990–2015

Year	Population			CBR			CDR		
	Medium	High	Low	Medium	High	Low	Medium	High	Low
1990	2,473,272	2,473,272	2,473,272	14.55	14.55	14.55	6.6	6.6	6.6
2000	2,603,790	2,667,893	2,653,863	9.45	13.15	10.95	5.7	5.97	4.95
2005	2,653,375	2,762,943	2,729,144	8.85	12.45	9.15	5.16	5.66	4.13
2006	2,663,166	2,781,717	2,742,858	8.7	12.31	8.79	5.16	5.59	3.96
2007	2,672,594	2,800,404	2,756,106	8.7	12.17	8.43	4.92	5.53	3.79
2008	2,682,696	2,819,002	2,768,880	8.7	12.03	8.07	4.8	5.47	3.63
2009	2,693,159	2,837,506	2,781,174	8.55	11.89	7.71	4.68	5.4	3.46
2010	2,703,581	2,855,913	2,792,980	8.55	11.75	7.35	4.56	5.34	3.3
2011	2,714,369	2,874,219	2,804,292	8.25	11.61	6.99	4.44	5.2	3.13
2012	2,724,710	2,892,637	2,815,102	8.25	11.47	6.63	4.26	5.14	2.97
2013	2,735,582	2,910,950	2,825,406	7.95	11.33	6.27	3.9	5.08	2.81
2014	2,746,661	2,929,155	2,835,196	7.65	11.19	5.91	3.66	5.01	2.64
2015	2,757,620	2,947,249	2,844,467	7.28	10.92	5.46	3.3	4.95	2.48

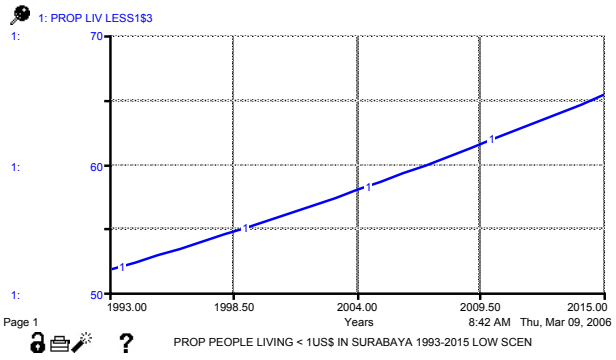

Figure 9. Trend of Proportion of People Who Live Less Than 1 US$/day. Based on Low Range Scenario

Achieving Primary Education

Educational attainment is one of the most crucial of indicators of human development, and hence of human dignity, and the future of a nation. The global declaration of Universal Primary Education is most significant to be adhered to in all social and human development endeavors. Furthermore, Indonesia has since the beginning of 1980s declared compulsory 9 years of education for all, i.e. primary and first secondary school, regardless of sex, race and religion. The following are the situation and projections for the city of Surabaya for the year 2015.

One of the eight MDGS is to achieve universal primary education. The following figures and tables show the trend of people in City of Surabaya who participate in primary, secondary, and high school level.

As one would note educational facilities are plentiful in Indonesia, especially for this basic primary education level. The government has over time build sufficient school buildings adequate number of graduates of teachers colleges. During the 1990s things were looking up and people were encouraged that even when compulsory education were to be raised to 12 years, facilities and teachers would be adequate to cater to the inherent needs.

However, with the onset of the monetary crisis in 1998, which soon after became a multi-facetted crisis, those aspirations were quenched. Not only were the school facilities deteriorating, the graduates from teachers colleges were seeking employment elsewhere.

Yet, the aspirations for better and higher education still came to the fore, resulting in the constant demand for primary education. With the increasing number of children entering the school-age brackets, the number of primary school students also increased steadily. Hence, what one would observe from the steady increase over time since 1990 to 2008. Prior to 2005 it is projected that a sharp increases would occur, due to factors in the birth rate, which although already declining, those babies would already have been borne, and thus entering their school-age years.

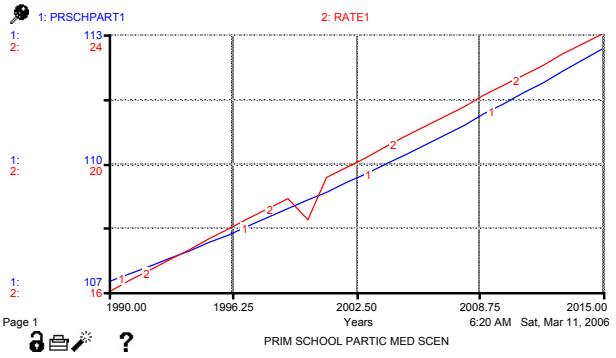

Figure 10. Trend of Proportion of People Who Participate in Primary School in City of Surabaya 1996–2015 Based on Medium Range Scenario

Table 2. Projection of Proportion of People Who Live Less than 1US$/day

Years	Medium	High	Low
1993	51.81	51.81	51.81
2000	55.83	56.27	55.62
2005	59.34	60.81	58.62
2006	60.12	61.87	59.25
2007	60.91	63.00	59.89
2008	61.73	64.18	60.54
2009	62.57	65.42	61.21
2010	63.44	66.73	61.88
2011	64.36	68.11	62.56
2012	65.30	69.55	63.26
2013	66.26	71.08	63.97
2014	67.25	72.64	64.68
2015	68.26	74.25	65.41

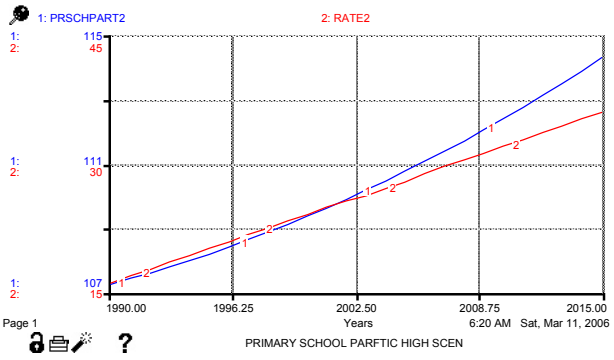

Figure 11. Trend of Proportion of People Who Participate in Primary School in City of Surabaya 1996–2015 Based on High Range Scenario

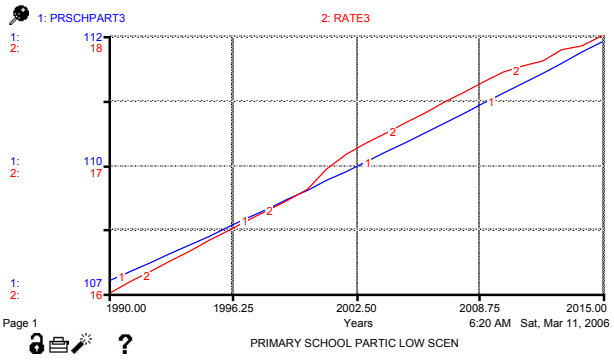

Figure 12. Trend of Proportion of People Who Participate in Primary School in City of Surabaya 1996–2015 Based on Low Range Scenario

By 2015 the primary school participation rates will be 112.665, 114.29%, and 111.87% based on respectively medium, high, and low scenarios. By considering the resources owned by City Government of Surabaya, Mayor can choose among three scenarios.

Child Mortality

One of the eight MDGs is reducing child mortality. Reducing child mortality is indicated by reducing infant mortality rate as well as under five mortality rate. The following figures and table show the trend of reducing infant mortality over time.

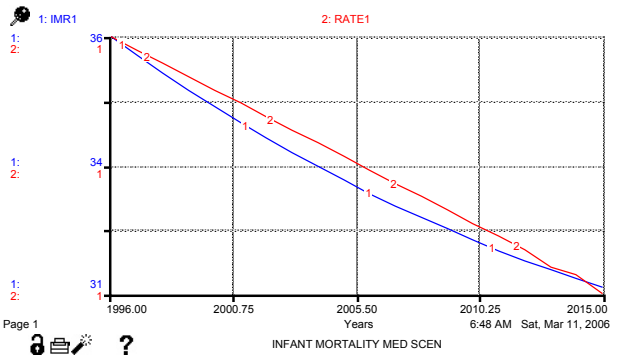

Figure 13. Trend of IMR in City of Surabaya 1996–2015 Based on Medium Range Scenario

Figure 14. Trend of IMR in City of Surabaya 1996–2015 Based on High Range Scenario

Table 3 Projection of Proportion of People Who Participate in Primary School in City of Surabaya, 1993–2015

Years	Medium		High		Low	
	PRSCP1	RATE1	PRSCP2	RATE2	PRSCP3	RATE3
1990	107.22	16.00	107.22	16.00	107.22	16.00
2000	109.10	18.20	109.34	24.00	108.99	16.80
2005	110.18	20.80	110.74	27.80	109.92	17.32
2006	110.41	21.12	111.05	28.80	110.11	17.40
2007	110.64	21.44	111.37	29.60	110.30	17.48
2008	110.88	21.76	111.70	30.40	110.49	17.56
2009	111.12	22.08	112.04	31.20	110.69	17.64
2010	111.37	22.40	112.39	32.00	110.88	17.72
2011	111.62	22.72	112.75	32.80	111.08	17.77
2012	111.87	23.04	113.12	33.60	111.28	17.81
2013	112.13	23.36	113.50	34.40	111.48	17.89
2014	112.39	23.68	113.89	35.20	111.67	17.92
2015	112.66	24.00	114.29	36.00	111.87	18.00

Figure 15. Trend of IMR in City of Surabaya 1996–2015 Based on Low Range Scenario

Whereas all three scenarios indicate rapid declining IMRs, the high estimate actually depicts a more than optimistic rate that realities of today could afford to support. Among those three estimations, the medium estimate appears to be the most feasible, and could safely be used to plan for a progressive achievement.

This is based on the assumption that the urban slum dwellings will still be prevalent by 2015, and furthermore the hygiene and sanitation conditions would still be below normal, although considerable improvements would already have been made.

Even with that modest decline, the impact of IMR on the longetivity of the people of Surabaya would be significant. Under-five Mortality Rate, or most commonly known as Child Mortality Rate (CMR) indicate the proportion of infant and children who will survive the hardships of early childhood to celebrate their fifth birthday. This is one of the major indicators of social well-being of the population, in this case of the Surabaya Municipality.

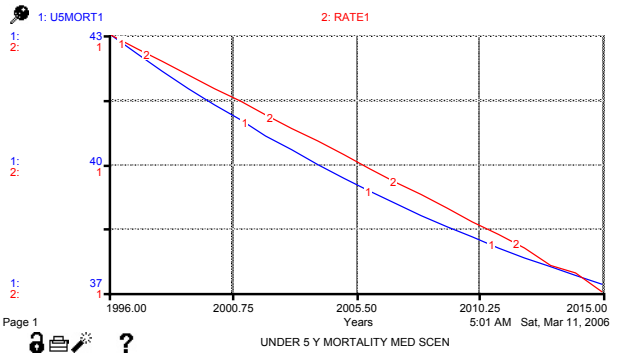

Figure 16. Trend of Under Five Mortality rate in City of Surabaya 1996–2015 Based on Medium Range Scenario

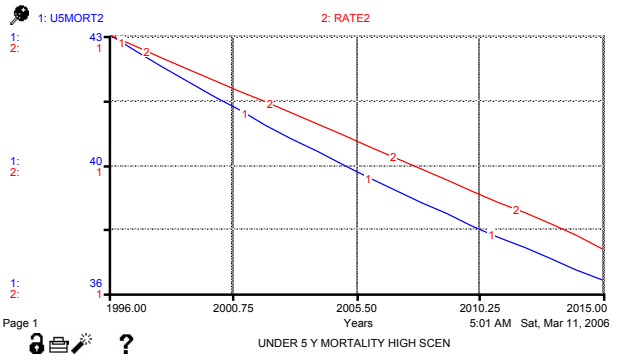

Figure 17. Trend of Under Five Mortality rate in City of Surabaya 1996–2015 Based on High Range Scenario

Table 4. Projection of IMR in City of Surabaya, 1993–2015

Years	Medium		High		Low	
	IMR1	RATE1	IMR2	RATE2	IMR3	RATE3
1996	36.000000	1.00	36.000000	1.00	36.000000	1.00
2000	34.635975	0.90	34.608709	0.95	34.650662	0.87
2005	33.198790	0.77	33.042395	0.88	33.283261	0.70
2006	32.944487	0.74	32.750631	0.87	33.049280	0.67
2007	32.700698	0.71	32.465700	0.86	32.827850	0.64
2008	32.467215	0.69	32.187469	0.84	32.618736	0.60
2009	32.243841	0.66	31.915807	0.83	32.421719	0.57
2010	32.030387	0.64	31.650586	0.82	32.236591	0.54
2011	31.826673	0.61	31.391685	0.81	32.063158	0.51
2012	31.632531	0.58	31.138982	0.79	31.901239	0.47
2013	31.447797	0.55	30.892361	0.78	31.750665	0.44
2014	31.274834	0.54	30.651709	0.77	31.611280	0.41
2015	31.107513	0.50	30.416917	0.75	31.482938	0.38

Table 5. Projection of Under Five Mortality Rate in City of Surabaya, 1993–2015

Years	Medium		High		Low	
	U5MORT1	RATE1	U5MORT2	RATE2	U5MORT3	RATE3
1996	43.00	1.00	43.00	1.00	43.00	1.00
2000	41.37	0.90	41.34	0.95	41.39	0.87
2005	39.65	0.77	39.47	0.88	39.76	0.70
2006	39.35	0.74	39.12	0.87	39.48	0.67
2007	39.06	0.71	38.78	0.86	39.21	0.64
2008	38.78	0.69	38.45	0.84	38.96	0.60
2009	38.51	0.66	38.12	0.83	38.73	0.57
2010	38.26	0.64	37.80	0.82	38.50	0.54
2011	38.02	0.61	37.50	0.81	38.30	0.51
2012	37.78	0.58	37.19	0.79	38.10	0.47
2013	37.56	0.55	36.90	0.78	37.92	0.44
2014	37.36	0.54	36.61	0.77	37.76	0.41
2015	37.16	0.50	36.33	0.75	37.60	0.38

Figure 18. Trend of Under Five Mortality rate in City of Surabaya 1996–2015 Based on Low Range Scenario

CONCLUSION

Based on Conclusion can be drawn based on the discussion above:

1. Based on medium, high and low range projection, by 2015 population size will be respectively 2,757,620; 2,947,249 and 2,844,467.
2. Based on medium, high and low range projection, bay 2015 the proportion of people who lived on less than US$ 1 per day will be respectively 6.26%, 74.25% and 65.41%.
3. Based on medium, high and low range projection, by 2015 the proportion of students who start grade 1 and reach grade 5 will be respectively 24%, 36%, and 18%.
4. Based on medium, high and low range projection, by 2015 infant mortality rate will be respectively 31.11, 30.42, and 31.48 per 1,000 live births. While under five years child death will be respectively 37.16, 36.33, and 37.60.
5. It is recommended to the government of City of Surabaya in achieving three of eight MDGs mentioned above to consider to the results of projections of proportion of people living on less than US1 per day, proportion of students reaching grade 5, infant and under five child mortality rate by selecting the scenario.

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