Challenges on Improved Life Spans in India—the Actuarial Implications

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Abstract

Life spans in India have been increasing for six decades, and now the change is noticeable. While this has challenged India, it has also led to many business opportunities. Noticing the challenge India, endeavoured on liberalization to arrive at an optimal solution. This was a planned move, and India experienced unprecedented economic growth in the past decade. This paper attempts to analyze the implications of this scenario, as set out in the synopsis. Every effort is taken to stick to the synopsis and digressions, if any, are only to sustain the flow. All currency is mentioned in U.S. dollars (converted at: 1 US $ = 40 Indian Rupees) for facility. The gist of the paper is as follows:

Present Conditions

1. Challenge of a large, rising population with increasing proportion of the aged
2. Changing demographic and socioeconomic profile and increasing life expectancy
3. Inadequacy of existing social security system and government's inability to handle the financial load
4. Large possibility of the problem spiralling in the future
5. Non-availability of adequate mortality and morbidity data
6. Large availability of employable youth and trained manpower

Conclusions and Concerns

1. Need of exploring alternative ways to tackle mortality study
2. Ensure professionalism in handling social security
3. Need to push revamp of social security systems and effectively implement the decisions
4. Concern on building up needed data
5. Uncertainty of effective implementation of reforms specified
6. Uncertainty of future developments in longevity study
7. Concern on acceptance of foreign/private players in the Indian market

Synopsis

A brief synopsis of items covered in the present paper is given below. The same has been proposed and accepted by the committee set up for the purpose. The narrative is in the same order as far as possible.

1. The history of life expectancy (LE) in India and its trend so far as recorded in the various censuses over the decades
2. A study on the results of experience studies in the Indian context vis-à-vis the United States and European countries has been attempted since the LE in India is following more or less on the same lines with a time lag of about 50 years. The latest census statistics available, as well as the experience studies of Indian insurers, have been used to the extent available. International mortality comparison, especially at the Asian level is also undertaken to study the shape of things that may come in India.
3. Special analysis of mortality/morbidity data on higher ages, say 85 and over since the generally accepted actuarial principles for smooth graduation of q_x over the ages such as Balducci Assumption etc. do not strictly hold good here. This is intended to be a detailed version including education, health status, marital status and causes of death and mode of living and financial status. Another important aspect covered with a special focus is mortality of surviving spouses after the death of a spouse, as the female LE in India is increasing considerably as compared to males.
4. Economic implications of increased life span with special reference to its social implications, as well as whether the social framework is adequate and whether the social security measures are in tune to meet the oncoming challenge.

1. Introduction

India is a land of contradictions, and this can be seen in the field of gerontology also. While it has achieved appreciable improvement in LE, infant and child mortality, medical aid, literacy, etc., there exist pockets, especially rural, that are disadvantaged with malnutrition, infectious diseases, poor medical aid, bad infrastructure, low living standards, inadequate insurance, etc. Concurrent presence of opposites is striking: while life spans have improved, government has not done enough for the old causing many to believe that having a long life is a problem.

Since over 50 percent of the present Indian population was born after 1982, the median age will be in the 20s for the next few decades, providing a large number of employable youth to power its growth on a par with China so much so that Indian economy is likely to be the fourth largest in the near future.

TABLE 1
India: Median Age Statistics (in years)[1]

Details/Year	2000	2015	2025	2030	2035	2040	2050
Median Age–India	22.70	26.50	29.90	31.70	33.60	35.30	38.60
Median Age–World	26.70	30.30	32.70	34.00	35.30	36.30	38.10
Median Age–More Developed Regions	37.40	40.80	43.00	44.10	45.00	45.50	45.70
Median Age–Less Developed Regions	24.10	28.20	30.80	32.20	33.60	34.80	36.90
Median Age–Least Developed Regions	18.50	20.40	22.10	23.10	24.30	25.40	27.90

But India is also graying fast. By 2016, 8.9 percent of the population will be above age 60 (113 million), which will increase to 13.3 percent by 2026.[9] To ensure that they are adequately cared for is a big challenge to policymakers—or else the family system may collapse and cause chaos. Full details of the population statistics are given in the Appendix.

India is the second most populous country with 16 percent of world population living in 2.42 percent of world area (3.3 million square kilometers).[7] Annual population growth rate is now 1.38 and population has grown in each census from 1901 except 1911-21.[7] It increased by 161.12 million during 1981-91, which was 10 times Australia's population and more than twice of Germany.[7] The growth rate fell from 24.66 percent (1971-81) to 23.85 percent (1981-91). [7] Population density per square kilometer rose from 216 (1981) to 273 (1993). LE is 63 years (male) and 66 (female); healthy LE is 53.5 (male) and 53.1 (female). [7] The neonatal mortality rate fell from 53/1,000 in 80s to 44/1,000 in 90s. [7] The poor spend 12 percent of income on health while the rich spend 2 percent. The untreated sick rural poor rose from 10 percent to 21 percent.[7] Over 2.5 million children die of contagious diseases.[7] Due to the scale, all changes are large and even a marginal change has a cascading effect. Urban GDP growth rate was 8 percent and the rural growth rate was 2 percent to 3 percent in the last decade.[6]

India is one of the few countries with high rural maternal mortality rates at 5.7 per 1,000.[7] Women, especially rural, have lower status of living, experience more episodes of illness than males and are unlikely to access timely health care. This is directly linked to poverty—the majority of poor are caught in the vicious circle of being ill due to poverty and being poor due to illness.

Precise studies were unavailable until recently to estimate the health-related burden for many diseases to ensure proper public health interventions. Reliable rural mortality data is scarce and morbidity data almost absent. It is no exaggeration that many rural deaths are unregistered—only 10 percent are medically certified![2] Data paucity makes analysis complex, as causes of death alone would reveal the sickness load. But sources like Survey of Causes of Death (SCD) reveal interesting findings—lack of morbidity data prevents a proper analysis to quantify the health care burden.

Though the standard of living is improving, the rich-poor gap is more glaring today. The indicator used to denote standard of living is per capita Purchasing Power Parity (PPP) adjusted Gross Domestic Product (GDP). PPP is the method of using the long-run equilibrium exchange rate of currencies to equalize their purchasing power. The adjustments to GDP on the basis of PPP are meant to give a better picture than comparing GDP using market exchange rates that fluctuate widely. In 2005, the per capita PPP adjusted GDP was U.S.$ 3,300 against $33,000 in the United States, $4,900 in China and about $26,000 in Europe.[6] It is one of the fastest growing economies with a growth rate of 8 percent between 2005 and over 9.2 percent in 2006 with 12 percent aimed for 2007 and 2008 to make it an important economy.[6] The middle class, about 250-300 million, is fast getting westernized. Though large disparities exist, the standard of living is rising and will be one-third of the developed world (in PPP dollars) by 2050.[6] As per 2006 statistics, 22 percent live below the poverty line, down from 50 percent in 1995.[6] India aims to eradicate poverty by 2020 with sustained economic growth. The standard of living in India ranges from limited rural medical facilities to world-class urban medical facilities.

Since 1947 India has allotted over 50 percent of the total plan outlays towards infrastructure development, the majority into irrigation, energy, transport, communications and social projects.[2] Infrastructure that was state-owned has been plagued by corruption, bureaucratic inefficiencies, urban bias and inability to scale investment. Low spend on power, construction, transportation, telecom and real estate at $31 billion (6 percent of GDP) compared to China's spending of $260 billion (20 percent of GDP) in 2002, barred India from getting a growth rate of 8 percent till 2005.[2] Now infrastructure is opened up to private sectors like airport construction to attract foreign capital.

Recent economic growth has helped upper and middle class more, but there still exist unbenefitted areas. National Sample Survey Organization (NSSO) estimates that 22.15 percent of population lives below poverty line in 2004-05 against 51.3 percent in 1977-78.[2] Startlingly, while 27 percent of the population is rural, 75 percent of the poor are rural; 35 percent live on less than $1/day and 80 percent live on $2/day.[6] Since the 1950s, India implemented partially successful five-year plans to eradicate poverty. Schemes like food for work and the National Rural Employment Program have attempted using the unemployed to build infrastructure. In 2005 Rural Employment Guarantee Bill, the largest program in terms of cost and coverage, promised 100 days' employment to every rural household. But it is debatable if economic reforms have reduced poverty significantly and have naturally put pressure on further economic reforms, especially those involving downsizing labor and agricultural subsidies.

But the challenge of a burgeoning population is real. In India, where a secure government job, agriculture or businesses were the major attractions, the present charm is a private job with good income though insecure. Unless a proper roadmap is prepared for future planning, catering to their future financial needs is difficult and might push future generations below the poverty line.

A study of this nature is very complex, as the present is a reflection of the past built over several generations of existence. The effects are huge and varied on diverse fields like genetics, present health, political situation, societal norms, financial standards, discipline, standard and style of living, family ties, outlook, etc. To untie all this is complex, and a reasonable attempt is made here.

2. History of Life Expectancy in India

A study of human LE is indeed fascinating, and it is impossible to fit it into a single mathematical model or formula, however sophisticated they are. Further it is noticed that Indian mortality experience closely mirrors the United States and Europe with a lag of about 50 years—this is likely to continue in the future though the lag might reduce, so a chronological and worldwide study is attempted.

LE has been increasing and converging worldwide except in parts of sub-Saharan Africa, which have seen a decline (partly attributable to the human immunodeficiency virus (HIV) epidemic). Quantum improvements in LE coincided with the introduction of sewers that greatly reduced disease. In the last few centuries, a strong statistical effect was caused by the near elimination of infant mortality in the Western world, and this is repeating in India. Worldwide average LE before modern era varied between 20-35 years depending upon local circumstances.[2] It is believed LE initially fell with the introduction of plant food and animal domestication because of infections caused by the increase in human settlement size and density and poor nutrition. LE improved to an extent in the Bronze Age but from the 19th century has increased greatly with better nutrition, public health practices and advances in medicine. An important development is the control of infant mortality, and maximum improvement is in richer countries.

LE improved sharply in the 20th century. For example, LE at birth in the United States was 49 years in 1901 and was 77 years in 2001, recording an increase of 57 percent. Similarly, in China, it rose from 35 years in the 1950s to 71 years. In India, it was 20 years in the 1950s and is 67 years in 2007 due to eradication of many infectious diseases and better nutrition. But one has to note that LE numbers tend to exaggerate this growth. Low levels of pre-modern LE are also skewed by the high infant and childhood mortality prevalent then. If one made it to the age of 40, he had an average of another 20 years to live. Improvements in medicine and nutrition have therefore mainly increased people living beyond childhood, with less effect on overall average life span. But LE declined in countries worst hit by AIDS, mainly sub-Saharan Africa. Similarly,

after the collapse of the Soviet Union, male LE fell to 59.9 years (below superannuation) and LE for women fell to 72.43 years (1999).[6]

Obesity and its complications are a major concern in many countries lately due to their potential of reducing LE due to rise of cancers, heart disease and diabetes. So far much improvement has been from preventing early deaths, but this may not stay true in the future as medical advancements aimed at better monitoring routine, medically significant test values, and simple blood pressure and clotting level control will prevent many sudden deaths or strokes. It is expected that at least 50 percent of American/Japanese babies born after 2000 might live to 90, and 10 percent to 100 years of age, while it is expected to rise to about 74 years in India.[6] It is hoped, with extended life spans, productive and non-debilitated years will be added to middle age placing a lot of responsibility.

But LE varies considerably on social class and gender due to public health diversity, medicine and nutrition. Variations also exist between groups due to gene stock. For example inter-ethnic differences in the United States in the early 20th century have now reduced.[4] Evolutionary theory explaining life span differences is that species living longer avoiding accidents, disease, predation, etc. might have genes for slow aging and good repair bringing out healthier offspring. Similarly, Indian female mortality decreased since independence. Differences still remain between men and women—women outlive men, but male LE is now improving faster. [7] In the United Kingdom, LE in the richest areas is 10 years more than in the poorest areas, and in India the difference is 12 years.[6] Detailed Indian mortality rates are given below.

TABLE 2
Life Expectancy at Birth by Sex (Years) 1950-2050[1]

Period	Male	Female	Both sexes combined	5 yearly Improvement (Combined)
1950-1955	38.10	36.60	37.40	0.00%
1955-1960	41.10	39.30	40.20	7.49%
1960-1965	44.60	42.60	43.60	8.46%
1965-1970	48.10	46.20	47.20	8.26%
1970-1975	51.40	50.00	50.70	7.42%
1975-1980	54.60	53.90	54.20	6.90%
1980-1985	56.80	56.60	56.60	4.43%
1985-1990	58.50	58.80	58.60	3.53%
1990-1995	59.90	60.80	60.20	2.73%
1995-2000	61.00	62.70	61.80	2.66%
2000-2005	61.70	64.20	62.90	1.78%
2005-2010	63.20	66.40	64.70	2.86%
2010-2015	65.00	68.50	66.60	2.94%
2015-2020	66.60	70.40	68.40	2.70%
2020-2025	68.00	72.10	70.00	2.34%
2025-2030	69.30	73.60	71.40	2.00%
2030-2035	70.50	74.90	72.60	1.68%
2035-2040	71.50	76.00	73.70	1.52%
2040-2045	72.50	77.00	74.70	1.36%
2045-2050	73.40	77.90	75.60	1.20%

TABLE 3
Death Rate (Age Adjusted) per 1,000 Population in India[7]

Year	Female	% Change	Male	% Change
1976	15.32	0.00%	14.7	0.00%
1977	15.3	-0.13%	14	-4.76%
1978	14.48	-5.36%	13.8	-1.43%
1979-1981	12.7	-12.29%	12.4	-10.14%
1984	12.8	0.79%	12.4	0.00%
1985-1989	11.1	-13.28%	11	-11.29%
1989-1991	9.8	-11.71%	10	-9.09%
1993	9.1	-7.14%	9.5	-5.00%
1994	8.9	-2.20%	9.6	1.05%
1996	8.9	0.00%	9.1	-5.21%
1997	8.41	-5.51%	8.8	-3.30%
1998	8.22	-7.64%	8.6	-5.49%
1999	7.91	-3.77%	8.2	-4.65%
2000	7.9	-0.13%	7.91	-3.54%
2001	7.41	-6.20%	7.8	-1.39%

LE is defined as the expected value of survival of human beings based on criteria like gender and geographic location. Usually it is the LE at births for a nation that is the same as expected age at death. Technically LE means the expected number of years remaining to live and can be calculated for any age by integrating the survival curve from that age to the final age. For example, for an extinct cohort, it is only the average of the ages at death since no allowance can usually be made for expected future mortality changes—i.e., mortality is assumed as frozen (except in some models like Lee-Carter). LE depends heavily on the criteria used for group selection. In countries with high infant mortality, LE at birth is highly sensitive to death rate in early years of life. Then, another measure like LE at age 1 or 2 is used to exclude the skew of infant mortality and reveal the effects of other causes. The mathematical formula for calculating LE is given below:

$$e_x = \sum_{t=0}^{\infty} t \, {}_tp_x q_{x+t}$$

The trend of LE in India shows steady progress as under:

TABLE 4
LE in India (Years) [2]

Year	LE
2000	61.50
2001	61.82
2002	62.14
2003	62.46
2004	62.78
2005	63.10

If this trend continues, it will touch 77.5 years by 2050 with '*b*' of 0.32. It is expected that the maximum human life span is about 125 years. Indian LE has risen from 20 years in the beginning of the 20th century to 67 years today.[7] Better medical care and low fertility means the elderly are growing fast. The older Indian population doubled in 25 years, while it took France 120 years.[6] Indian trend for the older population (defined as aged over 60 years) is given hereunder:

TABLE 5
Indian Trend for Older Population (>60 Years) [6]

Year	No. of old persons	% Increase
1901	12000000	0.00%
1951	19683400	64.03%
2001	78770600	300.19%
2025	168146000	113.46%

Disturbingly almost 90 percent of the old are in the unorganized sector with no social security.[7] Thirty percent are below the poverty line and 33 percent just marginally over it. Eighty percent live in rural areas without adequate medical infrastructure.[7] Seventy-five percent are illiterate and are into hard labour. Fifty-five percent of women over 60 are widows and unsupported.[7] Finally, out of over 1 billion population only about 210,000 are centenarians.[7] A detailed chart of life span across various countries is given in the appendix.

3. Census of India vis-à-vis the World

Census of India is the primary source of information on population. The first census was in 1871 and the latest was in March 2001, carried out by the office of the Registrar General and Census Commissioner. The population as at March 1, 2001 was 1,027,015,247, showing a rise of 21.34 percent on 1991. Female population increased by 0.3 percentage points to 48.4 percent. Maharashtra has the largest urban agglomeration while Delhi is the most urbanised market at over 93 percent. Some of the statistics of vital importance in the 2001 census are tabulated below:

Population: 1,095,351,995 (estimated as at July 2006) & 1,028,737,436
Rural Population: 742,617,747 (72.2%) (male: 381,668,992 & female: 360,948,755)
Urban Population: Age structure:
0–14 years: 30.8% (male 173,478,760/female 163,852,827)
15–64 years: 64.3% (male 363,876,219/female 340,181,764)
65 years and over: 4.9% (male 27,258,020/female 26,704,405) (2006 est.)
The average age of Indians is 26 years.

Population growth rate: 1.38% (2006 est.)

Birth rate: 22.01 births/1000 population (2006 est.)

Death rate: 8.18 deaths/1000 population (2006 est.)

Literacy rate: 64.8%

Unemployment Rate: 9.2%

Net migration rate: −0.07 migrant(s)/1,000 population (2006 est.)

Sex ratio:

At birth: 1.05 male(s)/female

Under 15 years: 1.06 male(s)/female

15–64 years: 1.07 male(s)/female

65 years and over: 1.02 male(s)/female

Total population: 1.06 male(s)/female (2006 est.)

Infant mortality rate: total: 54.63 deaths/1,000 live births, female: 55.18 deaths/1,000

LE at birth: Total: 64.71 years; Male: 63.9 years; Female: 65.57 years (2006 est.)

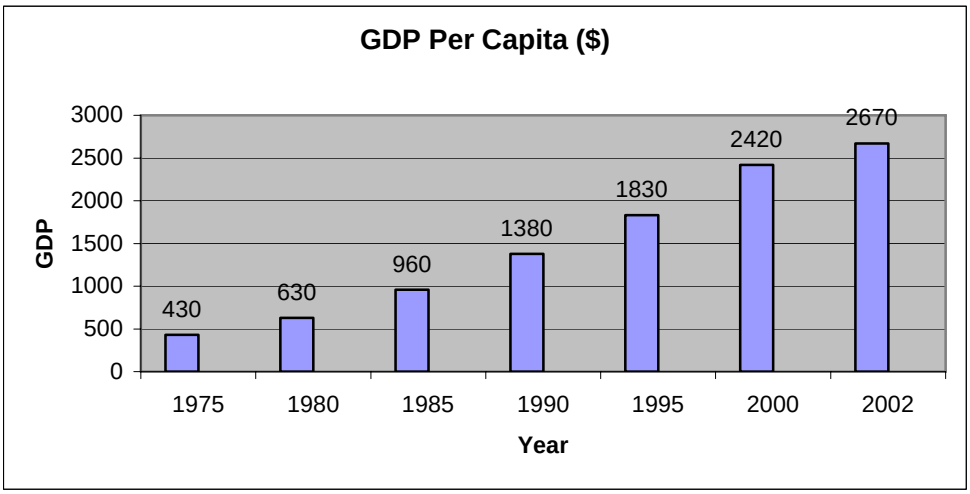
Total fertility rate: 2.73 children born/woman (2006 est.)

TABLE 6
Religion Wise Population Snapshots in India

Composition	Hindus	Muslims	Christians	Sikhs	Buddhists	Jains	Others
% total of population 2001	77.50	16.70	2.31	2.00	0.77	0.41	0.76
10-Yr Growth % (est '91-'01)	20.30	31.50	22.60	18.20	24.50	26.00	NA
Gender ratio* (avg. 933)	931	936	1009	893	953	950	992
Literacy rate (avg. 64.8)	65.1	59.1	80.3	69.4	72.7	94.1	47
Work Participation Rate	40	31.3	40	37.7	40	32.9	NA
Rural gender ratio	944	953	1001	895	958	937	995
Urban gender ratio	894	907	1026	886	944	941	966
Child gender ratio (0-6 yrs)	925	950	964	786	942	870	927

A study of various censuses of India, along with insurers' experience, shows that mortality has been constantly falling. The fall is more marked for females than males and it is expected that future fall in female mortality might taper off and male mortality improvement catch up. One also finds that the PPP adjusted GDP is increasing continuously indicating real growth.

CHART 1
Indian Trend of GDP (1975-2002) [6]



Comparing the Indian census with the world at large and with Asian countries like Japan, though perhaps not wholly justified, is interesting because it vividly highlights stark differences. In India about 4 percent of our population is over the age of 65. In parts of the world with better access to medicine and health care, these numbers are substantially higher. In Japan, for example, nearly 17 percent of the population is aged over 65 years. The average Japanese, Swiss or Canadian, with LE of 80 years, lives a full 25 percent longer than an Indian. Similarly, an average Chinese lives 12 percent longer than an Indian. Surprisingly, even a Sri Lankan, from a less developed country beset with social problems, lives almost 14 percent longer than an Indian. Longevity in India can improve and catch up with the developed nations in the future given the pace of development and past experience.

TABLE 7: Life Span in Major Countries[1]

Sl	Name	Life Span (2006 est.)	% difference
1	India	64.35	0.00%
2	Pakistan	63	-2.10%
3	China	72.27	12.31%
4	Japan	81.15	26.11%
5	South Korea	75.82	17.82%
6	United Kingdom	78.38	21.80%
7	United States	77.71	20.76%
8	Sri Lanka	73.17	13.71%
9	Germany	78.65	22.22%
10	Switzerland	80.39	24.93%
11	Canada	80.1	24.48%
12	Bangladesh	62.08	-3.53%

4. Analysis of Data

An analysis of data at higher ages is tricky since the generally accepted actuarial principles for smooth graduation of q_x over the ages like the Balducci Assumption, etc., do not strictly hold true. The main problems are lack of adequate number of lives, non-applicability of the Balducci Assumption, etc. Even Gompertz-Makeham's law breaks down at ages beyond 80 as the death rates do not increase as quickly as predicted due to late-life mortality deceleration, so age-independent and age-dependent components are insufficient to model death rates any more. An almost new mortality trend is seen in the advanced age mortality rates' decline and 'de-rectangularization' of the survival curve. Perhaps due to this, British actuaries stated in 2006 while releasing new tables by Continuous Mortality Investigation (CMI): "Actuaries Cannot Predict Life Expectancies—British actuaries no longer think they can provide reliable predictions for expected life expectancies."

Previous tables incorporated projections of future mortality, but this is not done with the latest tables because of uncertainty surrounding future improvements. The CMI has been undertaking significant research into possible methods of projecting mortality. This research is continuing, but it is not currently expected that this will lead to adoption of a specific projection basis. Instead actuaries and others using mortality projections should consider a range of scenarios. Nick Dumbreck, President of the Institute of Actuaries, commented: "Actuaries have

always been expected to satisfy themselves that using mortality tables published is appropriate for the particular purpose to which it is put and this is no different with the latest tables. But absence of mortality projections in the tables emphasises the need to consider the uncertainty in future mortality experience and to explain the repercussions of this to their employers and clients." Pension funds providing guaranteed benefits until death are in worse shape than they know. As the rate of increase in LE accelerates will governments make legal changes to relieve some liabilities?"

The actuaries show a table of dramatic mortality improvements at ages 65, 75 and 85. Stem cell therapies for heart disease, drugs to stop Alzheimer's plaque build-up, immunotherapy against cancer and many other treatments are going to cause big surges in longevity. Actuaries have no way of knowing when these treatments will come, but they already see big enough longevity changes to doubt their ability to predict future LE. It is hoped that actuarial escape velocity (AEV), i.e., the point where LE goes up faster than one year annually, is reachable in a few decades. Once we reach AEV, mortality in a year becomes less than mortality in the previous year. This is closer than one might guess. As people are already relatively long lived, even a 30 percent increase in healthy life span will give the first beneficiaries of rejuvenation therapies another 20 years to benefit from second-generation therapies that would give another 30 percent, and so on. Thus, if first-generation rejuvenation therapies were easily available and progress is maintained, we would be beyond AEV. But AEV is unlikely to be reached soon in India: it is likely to be actuarial entropy.

To fully appreciate and unravel the complexity of advanced age mortality, we might have to resort to reliability theory of aging and longevity, which is still in relative infancy. This attempts to get theoretical insights into mechanisms of biological aging and survival patterns by applying a general theory of systems failure allowing prediction of age-related failure kinetics for a system of given architecture (reliability structure) and given component reliability. This theory provides an optimistic perspective on the opportunities for healthy life-extension. As per this theory, human life span is not fixed but can be further increased through better body maintenance and repair and replacement of failed body parts. Some interesting conclusions are[4]:

1. Redundancy helps in understanding aging as well as nature of aging, and systems redundant in numbers of irreplaceable elements age over time, even if built of non-aging elements.
2. Paradoxically, the apparent rate of aging (measured as relative differences in failure rates between compared age groups) is *higher* for systems with higher redundancy levels.
3. Redundancy exhaustion over life could explain mortality convergence at later life when death rates are becoming relatively similar at advanced ages as well as the observed late-life mortality deceleration, levelling-off and mortality plateaus.
4. Living organisms seem to be formed with a high initial load of damage (HIDL hypothesis) and their life span and aging patterns may be sensitive to early-life conditions determining this initial damage load at early development. The idea of early-life programming of aging and longevity has important implications for developing early-life interventions to promote health and longevity and to predict them. For example we see that children with low birth-weight have a tendency to develop cardiac problems in later life.
5. Reliability theory explains why mortality rates increase exponentially with age viz. the Gompertz law taking into account the initial flaws. It also explains why organisms die according to Gompertz law, while technical devices usually fail as per Weibull law.
6. Reliability theory helps evolutionary theories to explain how age of onset of deleterious mutations can be postponed during evolution through increased initial redundancy levels.

This theory could be useful as the relative differences in mortality rates across nations and gender decrease with age, and although people living in developed countries might have longer life spans on average than people living in developing countries, those who achieve the oldest-old age in those countries die at rates relatively similar to the oldest-old in the developed countries. The concept of redundancy is crucial in this theory and refers to the ability or backup to accumulate some defects and yet survive. This theory also predicts late-life mortality deceleration and late-life mortality plateaus as a direct consequence of redundancy exhaustion at old ages and provides a good prediction and explanation with few general/realistic assumptions. So, reliability theory looks like a promising approach to develop comprehension of aging and

longevity by combining mathematical methods and specific biological knowledge rather than using either alone.

Some of the benefits India can get from reliability theory are:

1. The possibility of improving medical standards, which is necessary for reliability theory to be applied, is very essential given the vast areas without enough coverage and availability of talent pool. With this advance, the standard of living can be improved and enough data can also be obtained. This will in turn help create accurate predictions.
2. India possesses a large number of older people, providing a big sample size that can be used to make a detailed study across various social strata making an in-depth study possible.
3. Large-scale improvement in economic and social fields facilitates a study of this order as funds are available and a need is also present.

Overall, reliability theory provides a parsimonious explanation for many important aging-related phenomena and suggests a number of interesting testable predictions. Reliability theory seems to be a promising approach for developing a comprehensive theory of aging and longevity integrating mathematical methods with specific biological knowledge and evolutionary ideas.

Some interesting findings on study of mortality in India are:

1. The gender composition in India is almost uniformly in favour of the males, perhaps indicating the prevalence of prenatal sex selection which does not bode well in the long run.
2. Education influences mortality, especially for females, by improving self-care, opening up employment avenues, access to medical facilities and insurance, etc. A survey by Indian National Family Health, Government of India in 1992-93, shows that low levels of maternal education impact child mortality. In Kerala and Goa states, which have the highest literacy rates, female LE and sex ratio are better than the national average. Female literacy empowers women in living and to earn more too. Female labor input and property ownership can be key contributors too. There is a debate about the degree to

which each factor affects gender bias in mortality, but it is felt that female empowerment reduces gender-biased mortality.

3. Surviving spouse survival rate is affected by remarriage, education level, stress handling ability, family size and bonds, ability to find new vocation, etc. Usually surviving females live longer than males perhaps due to sympathetic acceptance by family and society. Male mortality is affected if employed on bereavement. Another factor affecting surviving male mortality is remarriage. A similar study for females is unfeasible as acceptance of widow remarriage is still less. Strangely, in joint life insurance, males tend to be the surviving partner during insurance term, male mortality being usually for accidents or 'unexplained' deaths. Female deaths are usually due to pregnancy complications or accidents, and the number of female accidents is suspicious. Female mortality improves rapidly on the end of insurance term, indicating moral hazard, anti-selection or other social problems. Increased surviving spouse mortality may be due to emotional reasons, unsupportive family, changed habits, etc.
4. Strangely economic development does not seem to improve female LE and sex ratio. Haryana and Punjab, two prosperous states, have the worst sex ratio, female infanticide and lower female life span as with Bihar and Orissa—the least developed states in India.[7] But overall mortality seems to improve with economic development.
5. Financial status does not affect females as much as males, i.e., they neither benefit significantly nor are worse off, perhaps explained by unwillingness to spend on their health.
6. It is a recent phenomenon that all the seasons come with a severity previously unknown viz. chillier winters, heavy rains and extremely hot summers. It is also common, going by number of death claims recorded by insurers in those times, that number of deaths especially of aged persons rises, especially in summers. It is also observed that states with moderate climate like Kerala have better LE than states with extreme climates like Rajasthan. Further research is needed on this, but for a large country it is difficult to incorporate this in pricing.

5. Social Security Measures—The Indian Scenario

Aging is a natural phenomenon, but the effects are staggering in India due to the large population and since the aged have grown faster, posing a serious challenge. Indians view old age as a time for rest when they depend on their families. Being healthy and having a caring family and financial security is desired. Forced savings at working age is seen as the ideal way to finance retirement, though this is used to meet short-term needs. Till recently retirement planning was a minor and cursory issue, though there is no state support. Working after retirement is unpopular except in emergencies or as social service and employers discourage recruiting elders due to regulations. The socio-economic impact of aging is serious. To complicate matters, existing traditional safety nets are vanishing viz. decline of joint families and state's inability to meet expenses. While the reasons for state's inability are economic, breakup of joint families is due to urbanization, growth aspirations, literacy, migration, etc. However the old contribute as family members, volunteers and workers, contributing $6 billion.[2] Superannuation liabilities forced the state to raise retirement age from 58 to 60 years in 1998, and it is unlikely to take any further liability. Only good social security can help, but getting that is tough since the state cannot do this alone and a new approach is needed. People now aged 60 are expected to live to 75 years of age and one aged 60 in 2020 will have another 20 years for which to plan.[6] India's social security system is outdated and needs to be revamped to control the problem.

TABLE 8
India: Population aged 60 and Above. Medium Variant 1950-2050[1]

Year	in '000s	% of population
1950	20098	5.6
1955	22171	5.6
1960	25106	5.7
1965	28719	5.8
1970	33223	6
1975	38489	6.2
1980	44604	6.5
1985	50626	6.6
1990	57843	6.8
1995	66485	7.1
2000	76586	7.5
2005	87509	7.9
2010	100889	8.5
2015	118858	9.4
2020	141810	10.6
2025	168146	12
2030	197292	13.6
2035	228192	15.3
2040	257406	16.8
2045	292488	18.7
2050	329683	20.7

5.1 Labor Market and Old Age Security

About 74.2 percent of the population is rural (1991 Census). [9] The per capita income in 2005 was $800.[6] India has an estimated 314 million workers of which 15.2 percent (47 million) are regular salaried, 53 percent (166 million) are self-employed and 31 percent (97 million) are casual workers.[7] Of salaried employees, 23 percent (11.13 million) are government employees who are eligible for pension. Forty-nine percent (23.18 million) of non-government salaried are covered under old age schemes.[7] So only 34 million (<11 percent) are in formal old age security.[7] Twenty-eight percent (13 million) of the salaried workforce and 268 million unorganized workers are excluded from existing provisions.[7] So 90 percent of workers are ineligible. Workers, now above poverty line, might sink below the poverty line in old age. Heavy health expenses also worsen this problem. Demographic transition and poor coverage might leave many destitute and a safety net or poverty alleviation program would be a staggering cost.

Problems in old age security are that many citizens have no pension; existing provisions have low returns and poor service. The trial is to have a comprehensive system independent of the state. A pioneering effort for this is Project 'Old Age Social and Income Security' (OASIS). As proposed in OASIS, the Pension Funds Regulatory and Development Authority (PFRDA) is formed, and it is likely that reforms will be as proposed. India is slow in pension reforms but has learnt from other countries and its own experience to: (1) avoid bundling collections, investment and disbursing payments; (2) avoid having government as the pension provider; and (3) have sound institutional infrastructure. OASIS reduces overhead by creating a new agency for record-keeping and selecting pension fund managers (PFMs) who bid lowest fees/expenses in an auction.

CHART 2
A Model of the Reformed Indian Pension Structure

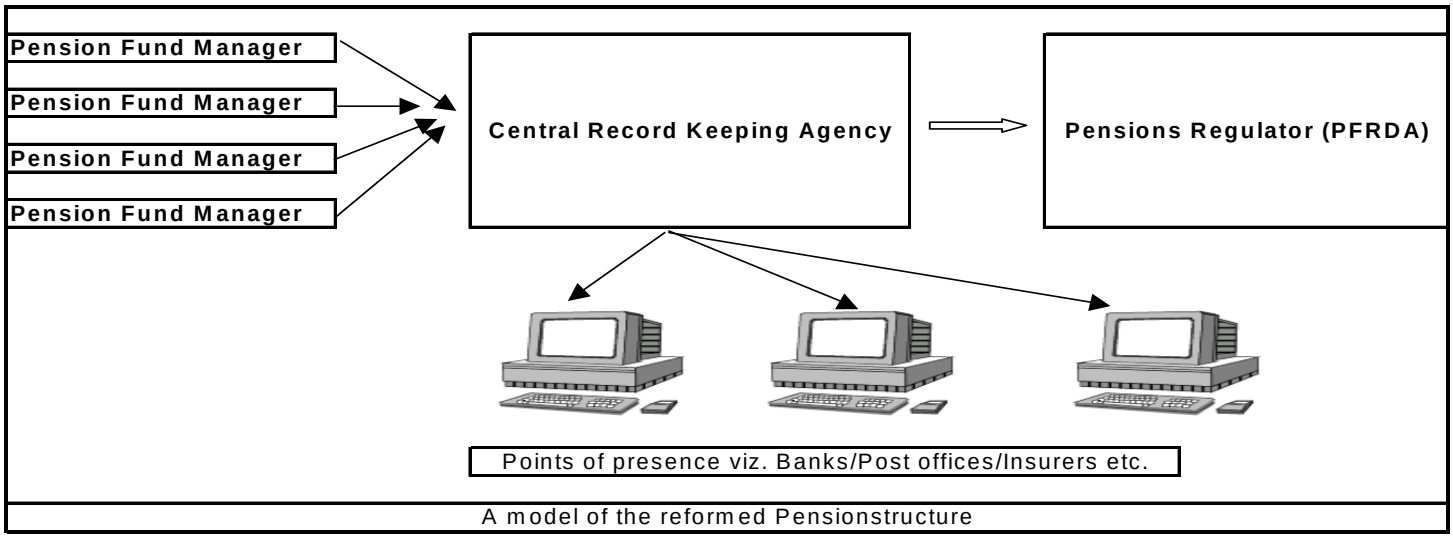
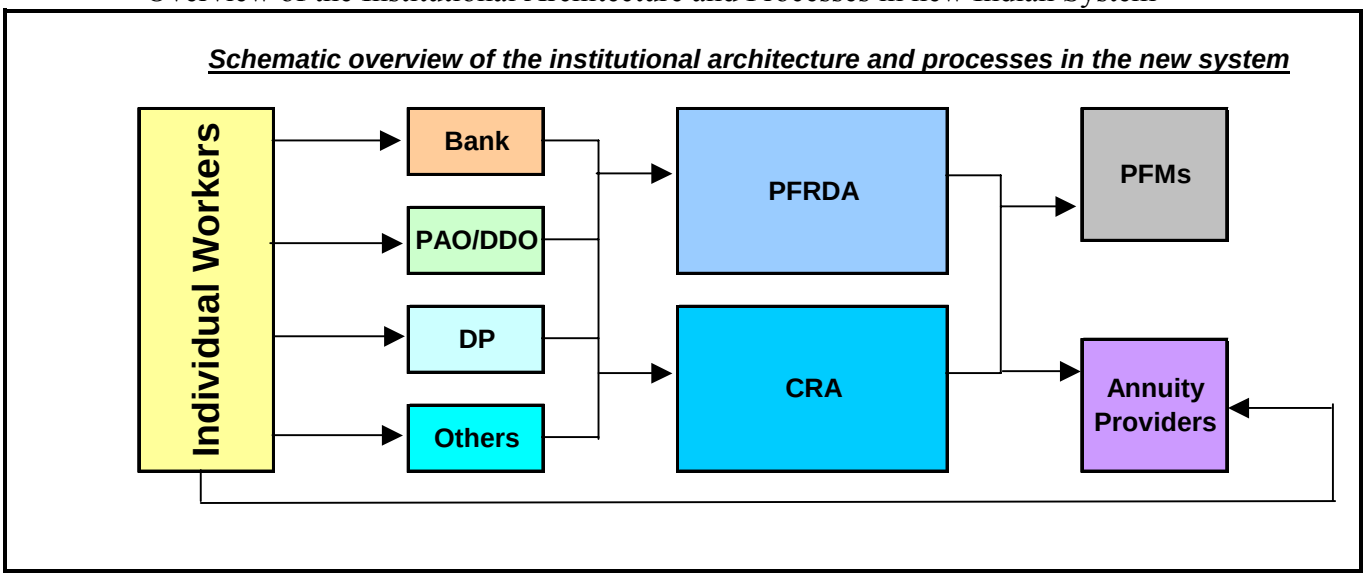


CHART 3
Overview of the Institutional Architecture and Processes in new Indian System



Key recommendations of OASIS are: (1) opening a single, life-long individual retirement account (IRA) with a unique IRA number with low minimum saving requirements ($2.5 per contribution and $12.5 annually) and freedom on investment; (2) a sound regulatory framework; and (3) contact through points of presence (POP) like post offices, banks, etc. The suggested investment options are given below:

TABLE 9
India-Suggested Investment Options

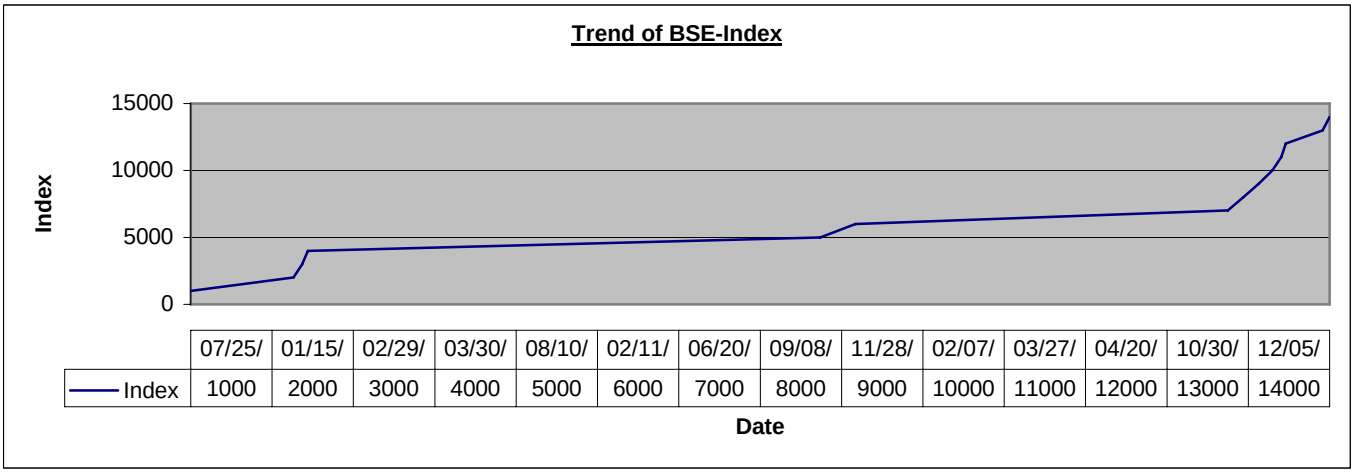
Sl. No.	Details	Safe Income (Low Risk)	Balanced Income (Medium Risk)	Growth (High Risk)
1	Government Paper	>50%	>30%	>25%
2	Corporate bonds	>30%	>30%	>25%
3	Domestic equity	>10%	>30%	>50%
3 (i)	of which, international equity may be limited to		>10%	>10%

Notes on Investments: 'Safe Income' guarantees against gross under-performance and Contribution Protection Insurance provides final pension assets are not lower than contributions made if contributions run for ten years. PFMs and insurers will be allowed to invest in benchmarked equity and derivatives as equity markets have been performing reasonably well.

There will be 18 investment choices and a default choice with option to change schemes

anytime. A Self Regulatory Organisation (SRO) will be registered with Indian Pensions Authority (IPA) for training and certification of retirement advisors (RAs).

CHART 4
Trend of BSE Index (Major Milestones)



Benefit Payments: Annuity providers to convert accumulation at retirement to a regular monthly pension or annuity until death on actuarially competitive rates.

Normal Withdrawals: At age 60 individuals can draw benefits from an IRA. The first $5,000 is earmarked to buy a monthly pension of $37.50, beyond which one can decide asset deployment. This amount will be periodically revised in tune with inflation. Withdrawal on retirement before age 60 is possible only if assets are annuitized.

Tax Treatment: Employees' and employers' contributions up to $3,000 will be tax-exempt while the self-employed get half this benefit. Maximum annual tax-free accretions would be $1500.[7] Now pension is taxable while provident fund withdrawals are not. In future all payments will be taxable except amounts used to buy annuities. Income on pension assets and provident funds will be tax-free. Shift is planned to EET taxation system (**E**xempt contributions, **E**xempt accumulations, **T**ax maturity). Now it is EEE (**E**xempt contributions, accumulations and maturity) taxation that is unsatisfactory, as income must be taxed once. Present taxation of provident funds is deficient as early withdrawals are allowed and are not effectively pension investment.

5.2 Micro-Credit and Withdrawals

Loans up to $125 are available if the IRA balance is over $250.[7] Only one loan, secured against pension assets, is allowed at a time. Subsequent retirement contributions are allocated towards loan repayment. A minimum annual pension contribution of $12.50 is applicable over loan repayments.[7] Premature withdrawals are allowed once $5,000 is accrued in an IRA and is allowed thrice, and a maximum of 33 percent of the balance over $5,000 is allowed in emergencies with a tax of 10 percent.[7]

5.3 Estimated Costs

Cost minimization is through centralized record keeping, contributions collection and introducing modern IT. Such costs may be met by annually charging 0.25 percent of pension assets.[7]

5.4 Indian Pensions Authority viz. PFRDA

Indian Pensions Authority (IPA) is a new regulator formed on Aug. 23, 2003 to supervise functioning and growth of the pension sector, enforcement of mandatory contributions, registration of Depositories, POPs, PFMs, etc. It will prescribe guidelines on investment and accounting, supervise withdrawals, taxation, fraud prevention and dispute resolution.

5.5 Reforms to Employees' Provident Fund (EPF)

The flaws of EPF are inefficient asset management, poor service **and** easy early withdrawals. So, the average balance of individuals leaving the system is only $625**, and** it is failing in building savings**.**[7] Hereafter premature withdrawals are allowed only on permanent disability, death or annuiti**z**ation. Participants can direct their contributions into the IRA that subsumes existing exempt funds and firms presently managing them should stop managing them.

5.6 Reforms to Employees' Pension Scheme, 1995

Employees Pension Scheme (EPS) must standardize benefits, based on an employer contribution rate of 10 percent. Government's contribution of 1.16 percent for pension accruals will be withdrawn.[7] It will be professionally managed with investment guidelines on the lines of OASIS. Annually an actuarial evaluation will be conducted and benefits/contributions adjusted to ensure there are no claims on government. Now, the Employee's Provident Fund Organisation (EPFO) does both fund management and annuity provision. Accumulated assets may be converted into monthly pensions using annuities once greater competition has appeared when EPS will outsource asset management (to professional fund managers) and benefits (to annuity providers).

5.7 Reforms to Public Provident Fund

Public Provident Fund (PPF) was intended for the unorganized sector. Sadly it is seen as a tax savings tool rather than for retirement planning. Existing PPF will continue as PPF-1 and a new PPF-2 will start. PPF-1 will stop accepting contributions but only service existing participants. Fresh contributions will be into PPF-2 and withdrawals are only at age 60, death or disability. Independent trustees will manage PPF-2 and 40 percent will be invested in government securities.[7]

5.8 National Senior Citizens' Fund

A National Senior Citizens' Fund (NSCF) is planned to educate individuals, do research and build infrastructure for social security. Government's contribution of 1.16 percent of wages to EPS will stop and be diverted to NSCF as corpus for first three years and then stopped. Twenty-five percent of premature and lump-sum withdrawal tax on PF will be diverted to this and run by professional trustees.[7]

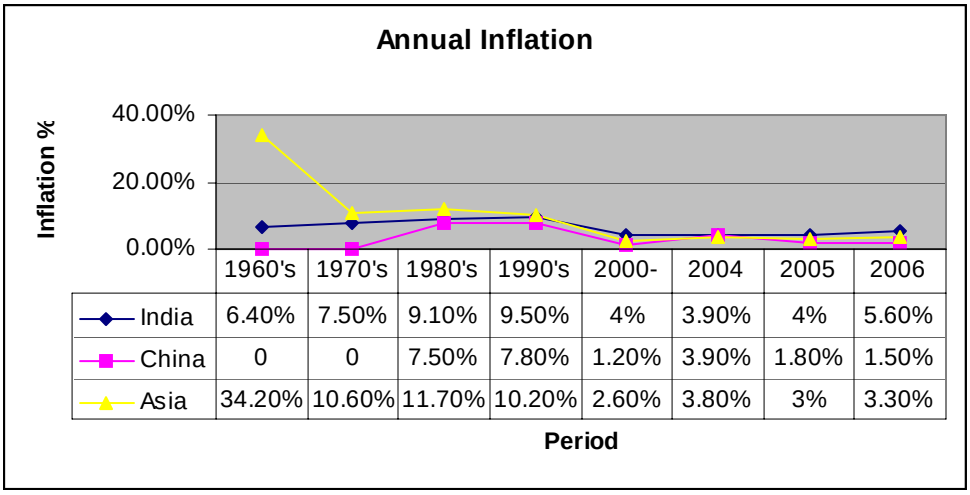
Overall we can say that the road ahead is long but a start is made and further success depends on the efforts of the future. However, public perception on insurance is changing—what was once seen as uneconomic is now seen for what it is. Proof of this is seen mainly in the growth seen in insurance with people willing to invest huge amounts hitherto un-thought of. For

example one has to see the news item in *The Economic Times* dated Sept. 4, 2004 reproduced hereunder:

> **LIC runs for cover as requests for $250 million policy rush in:** Life Insurance Corporation of India's top management is flabbergasted by proposals from less-known individuals to buy an insurance cover of $250 million……in this case, the policy that has been sought is a single premium policy and the premium is $175 million. With this kind of money being offered, LIC has little scope to ask for income justification.

With the introduction of "know your customer and anti-money laundering" guidelines business is healthier and safe. Further, one of the factors to be mainly considered, perhaps missing at the policy making stage at an individual level, is the inflation rate.

CHART 5
Trend of Annual Inflation India vs. China vs. Asia [2]



	1960's	1970's	1980's	1990's	2000-	2004	2005	2006
India	6.40%	7.50%	9.10%	9.50%	4%	3.90%	4%	5.60%
China	0	0	7.50%	7.80%	1.20%	3.90%	1.80%	1.50%
Asia	34.20%	10.60%	11.70%	10.20%	2.60%	3.80%	3%	3.30%

6. Conclusions

One good way to model advanced age mortality would be to have base-line mortality at an advanced age, say 70, and then model for future ages rather than continue with the same table since situations would have changed drastically. For example family history is not very relevant at this age if seen from childhood but would nevertheless be helpful in very roughly estimating

future life span—the way mortality changes with gender, assume it changes with age too—i.e., crossing a particular age threshold should be seen as the trigger to a separate state as crucial as gender, profession etc. It would be easier to model advanced age mortality that way as other factors can be isolated. It would be good to have a base rate at an advanced age and then model it further to include other factors through a Stepwise Cox Regression. Such factors as education, surviving spouse, hobbies, side-job, etc., can be added step wise with suitable weights. Another important weight could be Human Development Index and other qualitative aspects. Also such advances in life span also lead to tremendous challenges as well as opportunities. The challenges would be planning for improvement to ensure that social security net, financial planning for older age communities etc. are in place in time. Some administrative changes are needed; new rules would be put in place; new opportunities would develop; new players would enter; capital requirements worked out; regulatory issues sorted and systems put in place. As existing social security and overall preparedness is low, much depends on these steps and efficient implementation. Foreign countries experience and expertise are needed, but care should be taken to see that the society and economy could absorb the changes. New opportunities are many and majors like AIG, ING, Allianz, et al. are waiting to enter the pensions market. As India is cautious in accepting foreign players and expertise in sensitive areas, it would have the challenge of gaining acceptance and building a mutually beneficial relationship. It is safe to conclude that while there is a road map it is the execution and diligence that shall decide success. Recent developments indicate that this is taken seriously and points to a promising future. For example, consider the news in *The Economic Times* dated May 25, 2007:

> **India in ambitious plan to extend social security** : India has unveiled an ambitious plan to provide old-age and health protection to the country's estimated 370 million casual workers for the first time, officials said on Friday ……Workers in India's formal sector already pay contributions for pensions and health insurance. But they make up a mere 7 percent of the country's workforce. The new legislation aims at extending those benefits to around 370 million people who work in sectors such as agriculture…The proposed scheme involves workers being given personal "smart cards" and paying the equivalent of 1rupee (2.5 US cents) a day at local registration centres, officials said.

India may then see a day when age 70 is the new age 50 and elderly people are healthy, in control and enjoying the golden years more than ever.

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[7] Various Censuses of India

[8] OASIS Report of Ministry of Social Justice and Empowerment, Govt. of India

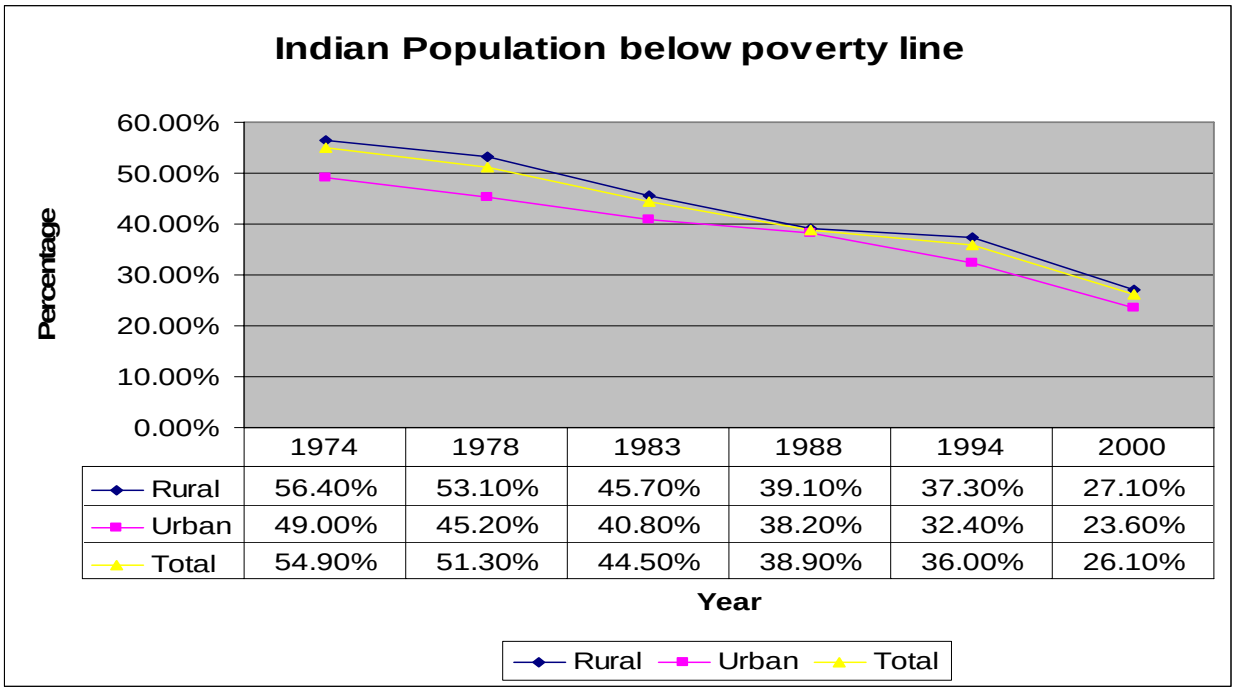
[9] 'A sustainable and scalable approach in Indian pension reform' of the Ministry of Finance, Govt. of India

Appendix 1

Appendix 1: Table of country-wise life expectancy (>60 years)

No.	Country	Exp.(years)	No.	Country	Exp.(years)	No.	Country	Exp.(years)
1	Andorra	83.51	48	Saudi Arabia	75.46	95	Vietnam	70.61
2	Singapore	81.62	49	United Arab Emirates	75.24	96	CapeVerde	70.45
3	San Marino	81.62	50	Mexico	75.19	97	Nicaragua	70.33
4	Japan	81.15	51	Tunisia	74.89	98	Palau	70.14
5	Sweden	80.4	52	Paraguay	74.89	99	Syria	70.03
6	Switzerland	80.39	53	Brunei	74.8	100	Marshall Islands	70.01
7	Australia	80.39	54	Serbia & Montenegro	74.73	101	Iran	69.96
8	Iceland	80.19	55	Dominica	74.65	102	Philippines	69.91
9	Canada	80.1	56	Slovakia	74.5	103	Federated States of Micronesia	69.75
10	Italy	79.68	57	Croatia	74.45	104	Indonesia	69.57
11	France	79.6	58	Poland	74.41	105	Tonga	69.53
12	Monaco	79.57	59	Venezuela	74.31	106	Peru	69.53
13	Liechtenstein	79.55	60	Bahrain	74.23	107	Fiji	69.53
14	Spain	79.52	61	Lithuania	73.97	108	Suriname	68.96
15	Norway	79.4	62	Macedonia	73.73	109	Trinidad & Tobago	68.91
16	Israel	79.32	63	Qatar	73.67	110	Belarus	68.72
17	Greece	79.09	64	Saint Vincent & Grenadines	73.62	111	Iraq	68.7
18	Austria	78.92	65	Saint Lucia	73.61	112	Kyrgyzstan	68.16
19	Malta	78.86	66	Sri Lanka	73.17	113	Tuvalu	68.01
20	Netherlands	78.81	67	Oman	73.13	114	Belize	67.49
21	Luxembourg	78.74	68	Algeria	73	115	Dominican Republic	67.26
22	New Zealand	78.66	69	Bosnia & Herzegovina	72.85	116	Russia	67.1
23	Germany	78.65	70	Solomon Islands	72.66	117	Sao Tome & Principe	66.99
24	Belgium	78.62	71	Lebanon	72.63	118	Ukraine	66.85
25	United Kingdom	78.38	72	Hungary	72.4	119	Kazakhstan	66.55
26	Finland	78.35	73	Mauritius	72.38	120	East Timor	65.9
27	Jordan	78.24	74	Turkey	72.36	121	Honduras	65.6
28	United States	77.71	75	China	72.27	122	Bahamas	65.54
29	Cyprus	77.65	76	Maldives	72.24	123	Guyana	65.5
30	Denmark	77.62	77	Saint Kitts & Nevis	72.15	124	Bolivia	65.5
31	Ireland	77.56	78	Bulgaria	72.03	125	Moldova	65.18
32	Portugal	77.53	79	Panama	71.94	126	Guatemala	65.14
33	Taiwan	77.26	80	Antigua & Barbuda	71.9	127	Papua New Guinea	64.93
34	Albania	77.24	81	Seychelles	71.82	128	Tajikistan	64.56
35	Cuba	77.23	82	Estonia	71.77	129	Grenada	64.53
36	Kuwait	77.03	83	Colombia	71.72	130	Mongolia	64.52
37	Costa Rica	76.84	84	Brazil	71.69	131	India	64.35
38	Chile	76.58	85	Thailand	71.57	132	Uzbekistan	64.19
39	Libya	76.5	86	Armenia	71.55	133	Azerbaijan	63.35
40	Jamaica	76.29	87	Barbados	71.41	134	Pakistan	63
41	Ecuador	76.21	88	North Korea	71.37	135	Nauru	62.73
42	Slovenia	76.14	89	Romania	71.35	136	Vanuatu	62.49
43	Uruguay	76.13	90	El Salvador	71.22	137	Bangladesh	62.08
44	Czech Republic	76.02	91	Latvia	71.05	138	Comoros	61.96
45	Argentina	75.91	92	Egypt	71	139	Yemen	61.75
46	Georgia	75.88	93	Samoa	70.72	140	Kiribati	61.71
47	South Korea	75.82	94	Morocco	70.66	141	Turkmenistan	61.39

Appendix 2: India Below Poverty Line Statistics[2]



	1974	1978	1983	1988	1994	2000
Rural	56.40%	53.10%	45.70%	39.10%	37.30%	27.10%
Urban	49.00%	45.20%	40.80%	38.20%	32.40%	23.60%
Total	54.90%	51.30%	44.50%	38.90%	36.00%	26.10%

Appendix 3: India state-wise Census statistics 2001[7]

Sl.	State	Population				Literacy rate %			Growth rate %	
		Male	Female	Sex ratio (males per 1,000 females)	Urban %	Total	Male	Female	1981-1991	1991-2001
1	Jammu and Kashmir	5,300,574	4,769,343	1,111.38	24.85%	54.46 %	65.75 %	41.82 %	30.34 %	29.04 %
2	Himachal Pradesh	3,085,256	2,991,992	1,031.17	9.79%	77.13 %	86.02 %	68.08 %	20.79 %	17.53 %
3	Punjab	12,963,362	11,325,934	1,144.57	33.95%	69.95 %	75.63 %	63.55 %	20.81 %	19.76 %
4	Chandigarh	508,224	392,690	1,294.21	89.78%	81.76 %	85.65 %	76.65 %	42.16 %	40.33 %
5	Uttaranchal	4,316,401	4,163,161	1,036.81	25.59%	72.28 %	84.01 %	60.26 %	24.23 %	19.20 %
6	Haryana	11,327,658	9,755,331	1,161.18	29.00%	68.59 %	79.25 %	56.31 %	27.41 %	28.06 %
7	Delhi	7,570,890	6,212,086	1,218.74	93.01%	81.82 %	87.37 %	75.00 %	51.45 %	46.31 %
8	Rajasthan	29,381,657	27,091,465	1,084.54	23.38%	61.03 %	76.46 %	44.34 %	28.44 %	28.33 %
9	Uttar Pradesh	87,466,301	78,586,558	1,112.99	20.78%	57.36 %	70.23 %	42.98 %	25.55 %	25.80 %
10	Bihar	43,153,964	39,724,832	1,086.32	10.47%	47.53 %	60.32 %	33.57 %	23.38 %	28.43 %
11	Sikkim	288,217	252,276	1,142.47	11.10%	69.68 %	76.73 %	61.46 %	28.47 %	32.98 %
12	Arunachal Pradesh	573,951	517,166	1,109.80	20.41%	54.74 %	64.07 %	44.24 %	36.83 %	26.21 %
13	Nagaland	1,041,686	946,950	1,100.04	17.74%	67.11 %	71.77 %	61.92 %	56.08 %	64.41 %
14	Manipur	1,207,338	1,181,296	1,022.05	23.88%	68.87 %	77.87 %	59.70 %	29.29 %	30.02 %
15	Mizoram	459,783	431,275	1,066.10	49.50%	88.49 %	90.69 %	86.13 %	39.70 %	29.18 %
16	Tripura	1,636,138	1,555,030	1,052.16	17.02%	73.66 %	81.47 %	65.41 %	34.30 %	15.74 %
17	Meghalaya	1,167,840	1,138,229	1,026.01	19.63%	63.31 %	66.14 %	60.41 %	32.86 %	29.94 %
18	Assam	13,787,799	12,850,608	1,072.93	12.72%	64.28 %	71.93 %	56.03 %	24.24 %	18.85 %
19	West Bengal	41,487,694	38,733,477	1,071.11	28.03%	69.22 %	77.58 %	60.22 %	24.73 %	17.84 %
20	Jharkhand	13,861,277	13,048,151	1,062.32	22.25%	54.13 %	67.94 %	39.38 %	24.03 %	23.19 %
21	Orissa	18,612,340	18,094,580	1,028.61	14.97%	63.61 %	75.95 %	50.97 %	20.06 %	15.94 %
22	Chhatisgarh	10,452,426	10,343,530	1,010.53	20.08%	65.18 %	77.86 %	52.40 %	25.73 %	18.06 %
23	Madhya Pradesh	31,456,873	28,928,245	1,087.41	26.67%	64.11 %	76.80 %	50.28 %	27.24 %	24.34 %
24	Gujarat	26,344,053	24,252,939	1,086.22	37.35%	69.97 %	80.5%	58.60 %	21.19 %	22.48 %
25	Daman & Diu	92,478	65,581	1,410.13	36.26%	81.09 %	88.40 %	70.37 %	28.62 %	55.59 %
26	Dadra & Nagar Haveli	121,731	98,720	1,233.09	22.89%	60.03 %	73.32 %	42.99 %	33.57 %	59.20 %
27	Maharashtra	50,334,270	46,417,977	1,084.37	42.40%	77.27 %	86.27 %	67.51 %	25.73 %	22.57 %
28	Andhra Pradesh	38,286,811	37,440,730	1,022.60	27.08%	61.11 %	70.85 %	51.17 %	24.20 %	13.86 %
29	Karnataka	26,856,343	25,877,615	1,037.82	33.98%	67.04 %	76.29 %	57.45 %	21.12 %	17.25 %
30	Goa	685,617	658,381	1,041.37	49.47%	82.32 %	88.88 %	75.51 %	16.08 %	14.89 %
31	Lakshadweep	31,118	29,477	1,055.67	44.47%	87.52 %	93.15 %	81.56 %	28.47 %	17.19 %
32	Kerala	15,468,664	16,369,955	944.94	25.97%	90.92 %	94.20 %	87.86 %	14.32 %	9.42 %
33	Tamil Nadu	31,268,654	30,842,185	1,013.83	43.86%	73.47 %	82.33 %	64.55 %	15.39 %	11.19 %
34	Pondicherry	486,705	487,124	999.14	66.57%	81.49 %	88.89 %	74.13 %	33.64 %	20.56 %
35	Andaman & Nicobar	192,985	163,280	1,181.93	32.67%	81.18 %	86.07 %	75.29 %	48.70 %	26.94 %
	INDIA Total	**531,277,078**	**495,738,169**	**1,071.69**	**27.78%**	**65.38%**	**75.85%**	**54.16%**	**23.86%**	**21.34%**

Appendix 4: India—Main Population Statistics [1]

Indicator	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Population (million)	372	406	446	494	549	614	689	771	860	954	1046	1134	1220	1303	1379	1447	1506	1554	1597	1632	1658
Male population (million)	193	211	232	258	287	320	359	402	448	496	543	588	631	672	710	743	771	794	814	830	842
Female population (million)	179	195	214	236	263	293	330	370	413	458	503	547	590	631	670	705	735	760	783	802	816
Sex ratio(males/100 females)	108	108.4	108.8	109.1	109.2	109.2	108.9	108.7	108.5	108.3	107.9	107.5	107	106.5	106	105.5	104.9	104.4	104	103.5	103.1
% aged 0-4	14.4	16.4	16.3	16	15.5	15.2	14.9	14.5	13.9	13.3	12.2	11.2	10.4	9.6	8.8	8	7.3	6.7	6.5	6.2	5.9
% aged 5-14	23.1	22.4	24.1	25.5	25.3	24.9	24.5	24.2	23.9	23.3	22.8	21.8	20.3	19.1	17.9	16.8	15.6	14.4	13.3	12.6	12.3
% aged 15-24	19.4	18.8	17.9	17.3	18.6	19.7	19.6	19.3	19.1	19.1	19.2	19.3	19.3	18.7	17.8	17	16.3	15.5	14.6	13.6	12.7
% aged over 60	5.4	5.1	5.2	5.3	5.5	5.6	5.8	6	6.3	6.6	7.1	7.5	8	9	10.2	11.5	12.9	14.4	16.2	18.1	20.2
% aged over 65	3.1	3.1	3	3.2	3.3	3.4	3.6	3.7	3.9	4.2	4.6	5	5.3	5.8	6.7	7.7	8.8	10	11.3	12.8	14.5
% aged over 80	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.4	1.8	2.2	2.7	3.1
Median age	21.3	20.7	20.2	19.6	19.3	19.7	20.1	20.6	21.2	21.8	22.7	23.8	25	26.5	28.1	29.9	31.7	33.6	35.3	37	38.6
Population density (sq. km)	113	123	136	150	167	187	209	235	262	290	318	345	371	396	420	440	458	473	486	496	504

Indicator	1950-1955	1955-1960	1960-1965	1965-1970	1970-1975	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040	2040-2045	2045-2050
Population change per year (r	7	8	10	11	13	15	17	18	19	18	18	17	16	15	14	12	10	9	7	5
Births per year (million)	17	18	19	20	22	23	25	27	28	28	27	27	27	26	24	23	22	21	21	20
Deaths per year (million)	10	10	10	9	9	8	8	9	9	9	10	10	10	10	10	11	12	13	14	15
Population growth rate (%)	1.73	1.9	2.04	2.13	2.22	2.3	2.26	2.19	2.08	1.84	1.62	1.46	1.31	1.14	0.97	0.79	0.63	0.54	0.44	0.32
Birth rate (per 1,000 populatio	43.3	42.3	40.7	38.8	37.3	36	34.3	32.5	30.7	27.7	25.1	23	21	19.1	17.2	15.5	14.1	13.6	13	12.3
Total fertility rate (per woman)	5.91	5.9	5.82	5.61	5.26	4.89	4.5	4.15	3.86	3.46	3.11	2.81	2.54	2.32	2.13	1.97	1.86	1.85	1.85	1.85
Net reproduction rate (per wo	1.63	1.72	1.82	1.87	1.86	1.83	1.74	1.65	1.56	1.42	1.3	1.2	1.11	1.03	0.96	0.89	0.85	0.85	0.85	0.86
Infant mortality rate (per 1,000	165.7	153.1	140.3	128.1	116.8	104.4	94.7	85.7	77.2	69.5	62.5	55	48.8	43.4	38.9	35	31.6	28.3	25.4	23