CS752: System Dynamics

Project Submission - 3

Group Name: Causal Thinkers

Name	Roll No.
Arijeet De	23M0742
Ronak Upasham	23M0793
Mohiboddin Shaikh	23M0827

India’s Demographic Edge: A Race Against Time

Problem Statement:

Demographic Opportunity & Risk: India has a large youth population that can drive economic growth if properly harnessed, but neglecting investment could lead to a demographic disaster.

Key Challenges:

- Gaps in education quality and skill development.
- Limited employment opportunities.
- Inadequate infrastructure.

Potential Consequences (if no action is taken):

- Rising unemployment and economic stagnation.
- Social instability and increased burden on welfare systems.
- Loss of global competitiveness.

What strategic actions must India take to effectively utilize its youth population and prevent it from becoming a liability in the next few decades?

Objective:

- Analyze the risk of India’s large youth population becoming a demographic disaster if not effectively utilized.
- Assess the impact of government funding on human capital development and economic outcomes.
- Explore policy interventions to balance education, infrastructure, and social welfare investments.
- Identify strategies to maximize workforce development and economic growth.

Scope:

- The model encompasses four interconnected systems: population demographics, government finance, education infrastructure, and economic development
- Time horizon spans multiple decades to capture full lifecycle effects from education investment to workforce outcomes to retirement
- Geographical scope is India with aggregated population segments rather than individual-level dynamics
- The model focuses on macro-level policy decisions rather than micro-level behavioral changes
- Includes basic representation of economic feedback loops without detailed industry-specific modeling

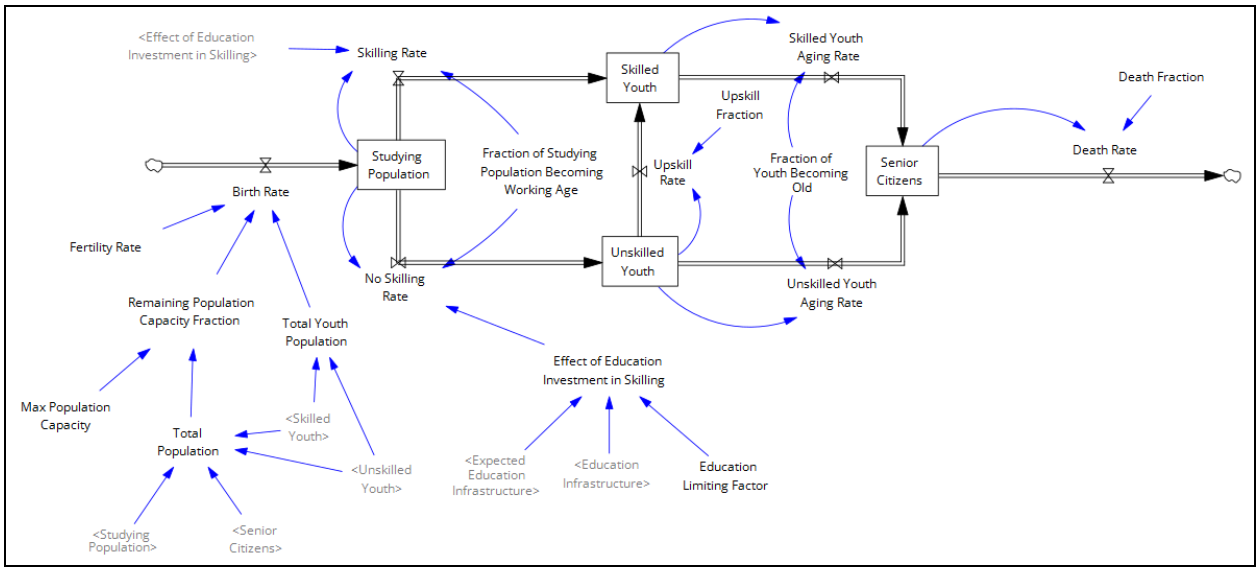
Assumptions:

- Population segments (studying, skilled youth, unskilled youth, senior citizens) adequately represent key demographic groups for policy analysis
- Education investment has a direct and quantifiable impact on skilling rates and workforce quality
- Economic infrastructure directly influences company formation and job creation in a predictable ratio
- Tax revenue generation can be reasonably modeled based on workforce size and skill composition
- Infrastructure degradation occurs at consistent rates that can be offset by maintenance investment
- Corruption affects government expenditure efficiency in a quantifiable and consistent manner
- Population growth dynamics (birth rates, death rates) follow established demographic patterns
- Labor market efficiently matches skilled and unskilled workers to appropriate job categories
- Government budget allocation decisions follow the modeled investment fractions without major policy shifts
- External economic shocks or global market factors are not explicitly modeled

Work Done:

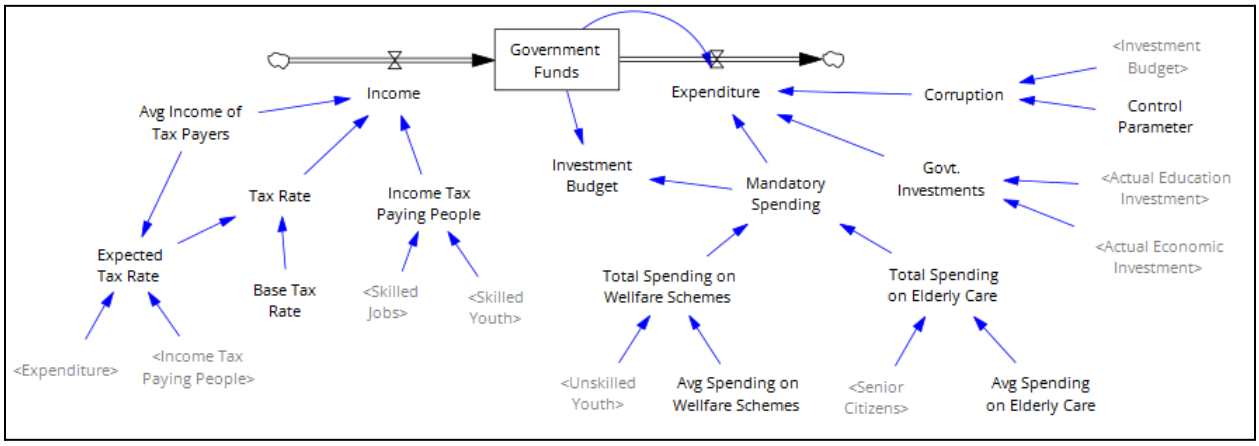
- Added a Stock for Education Infrastructure and Economic Infrastructure.
- Added a balancing loop which makes sure fertility rate lowers as the total population approaches a certain capacity.
- Added a causal link between the expenditure and tax rate which will make sure if the country becomes developed enough then there would be less need for expenditure thus reducing taxes.
- Added formulas and values to all the Auxiliary variables, Flow variables and Stocks.
- Renamed a few variables because they were causing confusion.
- Made use of Shadow variables to make the SFD model presentable.
- Used articles and research papers to come up with values for some variables.

SFD Model:



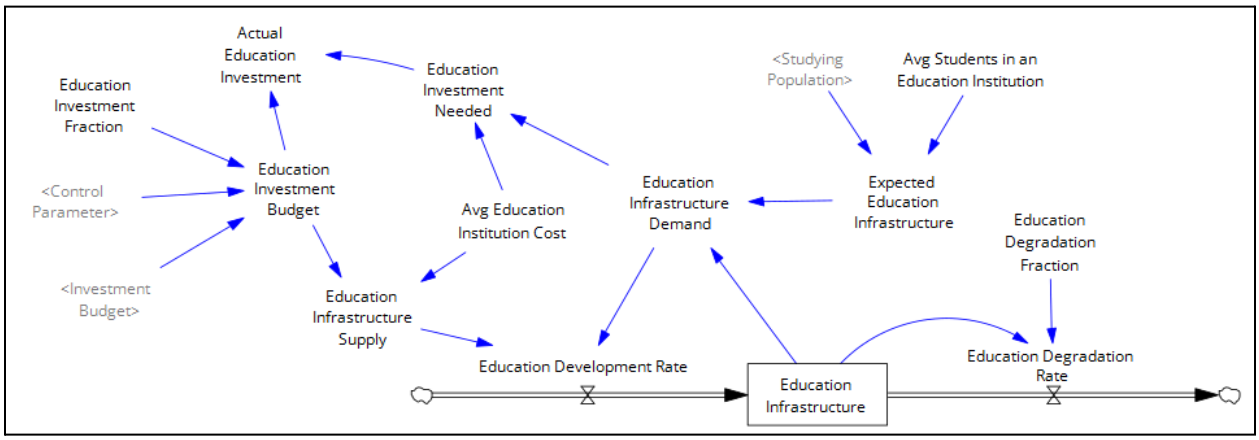
Population Dynamics

- The model tracks multiple population segments: Studying Population, Skilled Youth, Unskilled Youth, and Senior Citizens
- Population flows between these segments based on rates like Birth Rate, Skilling Rate, No Skilling Rate, and Aging Rates
- Factors like Fertility Rate and Death Rate influence overall population changes
- Total Population is calculated by summing all population segments
- Population capacity constraints are included (Max Population Capacity)



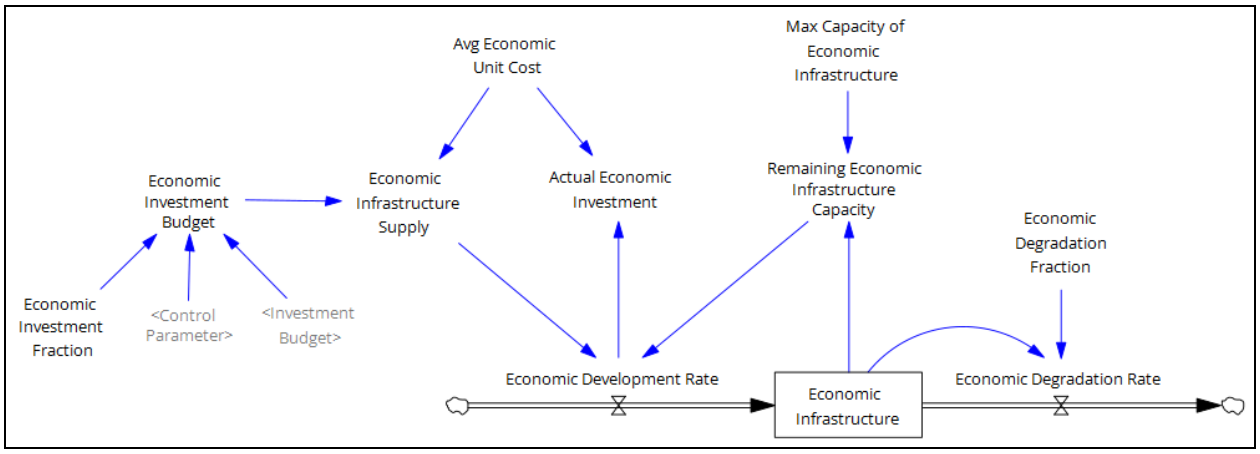
Government Funding and Taxation

- Government Funds are modeled as a stock with Income and Expenditure flows
- Income is influenced by Tax Rate, Avg Income of Taxpayers, and Income Tax Paying People
- Expenditure is divided into categories: Investment Budget, Mandatory Spending, Govt. Investments
- Spending categories include welfare schemes and elderly care
- Corruption is modeled as a factor affecting expenditure



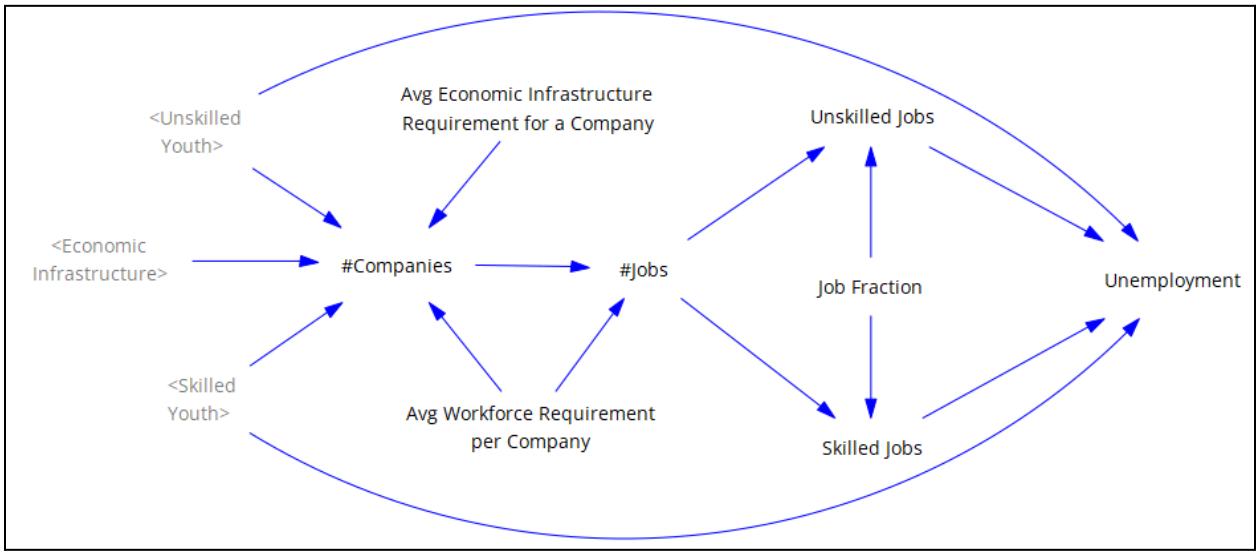
Education Infrastructure

- Education Infrastructure is modeled as a stock with development and degradation rates
- Education Investment Budget determines infrastructure supply
- Education Infrastructure Demand is influenced by studying population and average students per institution
- The gap between needed and actual education investment is captured
- Education degradation is incorporated to model maintenance requirements



Economic Infrastructure

- Economic Infrastructure is modeled similarly to Education Infrastructure
- Economic Investment Budget determines infrastructure development
- Factors like Average Economic Unit Cost affect economic development rate
- Economic infrastructure has a maximum capacity with degradation over time



Employment and Economic Outcomes

- Economic Infrastructure and population segments determine the number of companies
- Companies create jobs based on workforce requirements
- Jobs are divided into Skilled and Unskilled categories based on Job Fraction
- Unemployment is affected by available jobs and workforce
- Feedback loops exist between population segments and job availability

Key Interactions and Feedback Loops:

1. **Education-Employment Loop**: Education investment affects skilling rates, which increases skilled youth population, who contribute more to income tax, enabling more education investment
2. **Infrastructure-Economic Development Loop**: Government investment in economic infrastructure leads to more companies and jobs, increasing tax income, which can fund more infrastructure
3. **Population-Resource Balance**: Population growth increases demands on education and economic systems while potentially contributing to the workforce
4. **Aging Population Cycle**: Youth eventually become senior citizens, affecting welfare spending requirements and changing the workforce composition
5. **Infrastructure Maintenance Cycle**: Both education and economic infrastructure face degradation, requiring ongoing investment to maintain capacity

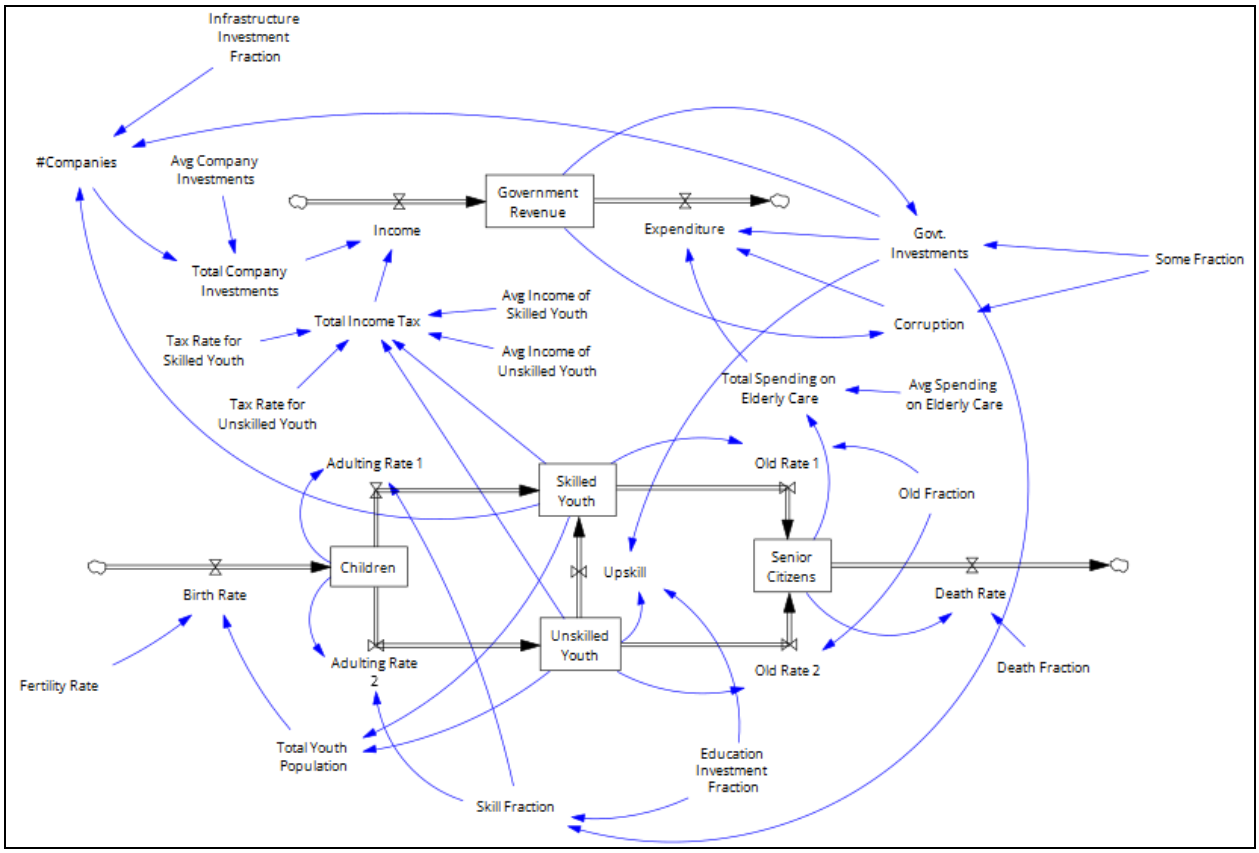
References:

https://www.indiatvnews.com/news/india/sonia-gandhi-demands-raising-minimum-wages-guaranteed-workdays-under-mgnrega-parliament-budget-session-2025-03-18-981118

https://www.cnbctv18.com/business/finance/fy23-direct-tax-collection-interesting-facts-income-tax-data-19468376.htm#:~:text=This%20means%20the%20average%20income,%E2%82%B97.24%20lakh%20in%20FY23.

Appendix

Second Submission:



Key Dynamics in the Model:

Youth Population Flow

- Birth rate determines the number of **Children** entering the system.
- As children grow, they transition into either **Skilled Youth** (if there's enough investment in education) or **Unskilled Youth** (if education investment is low).
- Skilled and Unskilled Youth eventually age into **Senior Citizens**, increasing the dependency ratio over time.
- High dependency with a low-skilled workforce leads to an economic burden, signifying a **demographic disaster**.

Economic Contributions & Government Role

- **Skilled Youth** earn higher wages, contributing more to **income tax** and boosting **government revenue**.
- **Unskilled Youth** earn lower wages, leading to lower tax contributions and economic inefficiencies.
- The government's expenditure depends on **"some_fraction"**:
  - A **higher fraction** ensures more money is invested in **education (skill development) and infrastructure**, increasing productivity and economic stability.
  - A **lower fraction** leads to more **corruption**, reducing effective investments and causing a **demographic disaster** with high unemployment and low economic growth.

Feedback Loops

- High investment in education creates more **Skilled Youth**, increasing national income and tax revenue, leading to sustainable economic growth (**demographic dividend**).
- Low investment results in a larger **Unskilled Youth** population, low productivity, and higher dependency on social spending, pushing the economy towards **demographic disaster**.
- **Elderly care costs** increase over time, adding financial strain if the workforce is not productive enough to support them.

Takeaways:

The **"some_fraction"** parameter serves as a policy lever:

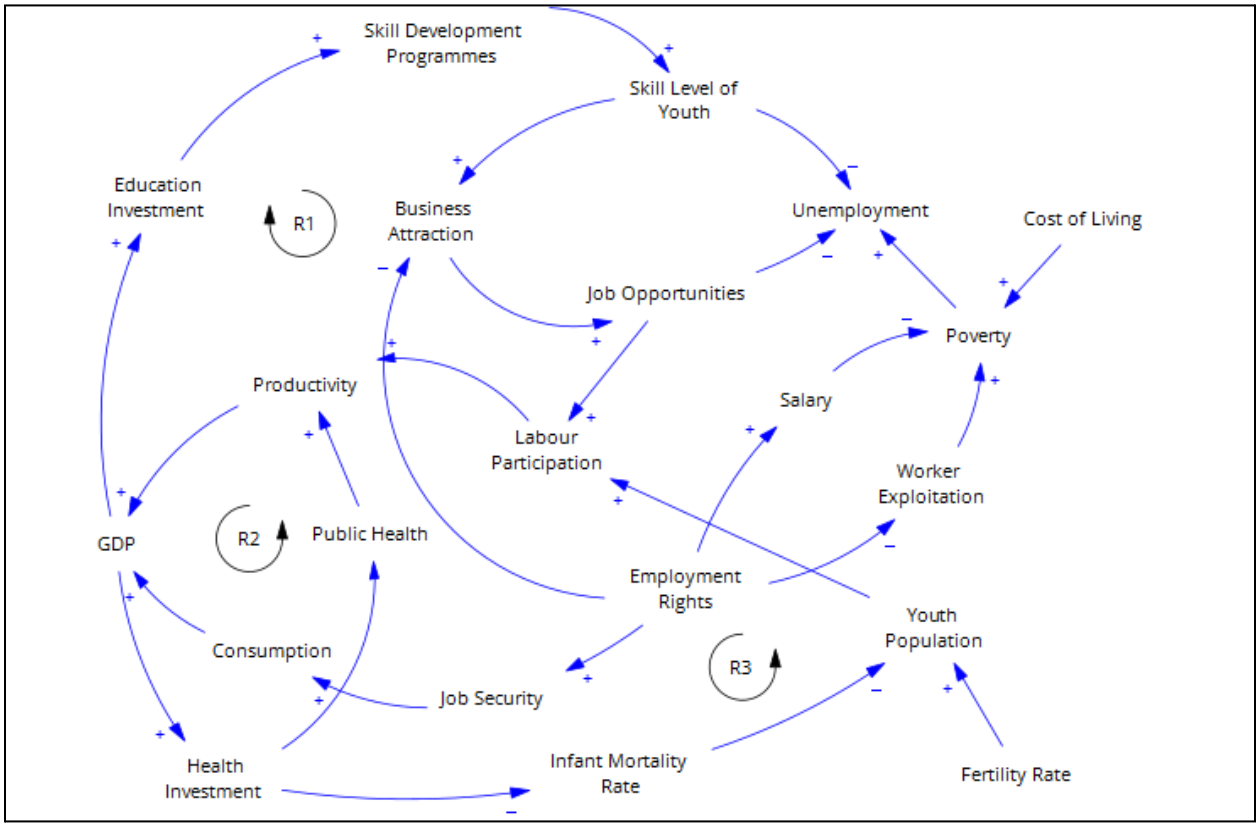
- **Towards 1** → Sustainable growth via skill development and infrastructure.
- **Towards 0** → Economic stagnation due to corruption and a poorly skilled workforce.

The model can help analyze **policy decisions**, showing how investments (or lack thereof) determine whether a country experiences a **youth-driven economic boom (dividend) or a disaster**.

Papers:

[1] Hans, V., 2023. India's Demographic Dividend: Opportunities and Policies. *India's Demographic Dividend: Opportunities and Policies (October 22, 2023)*.
[2] Jain, N. and Goli, S., 2022. Potential demographic dividend for India, 2001 to 2061: a macro-simulation projection using the spectrum model. *SN Social Sciences*, *2*(9), p.171.
[3] Nejat, E.R.K., Çabuk, H.A. and Sanlı, A.T.E.Ş., Long-Run Growth and Physical Capital-Human Capital Concentration.

First Submission:



Background / Literature Survey

In [4] it has been discussed that India is experiencing a significant demographic shift, where the working-age population is increasing, presenting an opportunity for economic growth. This shift occurs when a country transitions from high fertility and mortality rates to lower levels, creating a demographic window of opportunity. Many economists predict that India will benefit from this youthful population. India's average age of 29 could contribute an additional 2% to its GDP annually and account for 25% of the global increase in the working-age population until 2040.

Despite this potential, India faces several obstacles that may hinder its ability to reap the benefits of its demographic dividend. The labour market has an imbalance, with some skills in surplus and others in shortage, limiting economic efficiency. Poverty remains a significant issue, as lower-income households struggle with access to quality education, healthcare, and nourishment, negatively impacting youth productivity. Many young workers accept jobs with poor working conditions due to economic insecurity, leading to long hours, low wages, and job instability. Employment rights are often overlooked, with workers facing termination without notice and a lack of benefits, contributing to a growing number of working poor.

Furthermore, job insecurity prevents employees from planning their futures, while the education system fails to meet market demands. The high cost and limited availability of vocational training restrict opportunities for many young individuals. Without adequate skill development, the workforce remains underprepared for industry needs, limiting the overall productivity of the economy. Addressing these challenges through effective policies in education, employment rights, and economic inclusion is crucial to ensuring that India's growing youth population contributes meaningfully to national development rather than becoming a burden on the economy.

In [2], it has been argued that the transformation of demographic potential into demographic dividend depends on the adoption of a state-sponsored socio-economic policy regime. This should focus on public health and education to equip youth with skills required for the twenty-first century and ensure macroeconomic policies that optimize human resource utilization. Without such interventions, the demographic dividend will remain an unfulfilled promise and may turn into a demographic burden instead of an advantage.

References

[1] Singh, Paramjit, and Surinder Kumar. "Demographic dividend in the age of neoliberal capitalism: an analysis of employment and employability in India." The Indian Journal of Labour Economics 64.3 (2021): 595-619.

[2] Parida, Jajati Keshari, and S. Madheswaran. "Harnessing demographic dividend before it is lost forever in India." The Indian Journal of Labour Economics 66.1 (2023): 61-79.

[3] Oghenekohwo, Jonathan E., and Ekima A. Frank-Oputu. "Literacy education and sustainable development in developing societies." International Journal of Education and Literacy Studies 5.2 (2017): 126-131.

[4] Naik, Kasturi, and Anita Bobade. "Youth in India: Demographic Dividend or Demographic Disaster." 9th Annual Conference of the EuroMed Academy of Business. 2016.