## Assumptions for Macro chapter

Our approach assumes that infrastructure has a positive externality. Infrastructure investment creates demand for investment goods and contributes to the efficiency the economy. Productivity is a transmission channel for positive externalities of infrastructure investment. In our approach, these productivity impacts are defined for the national economy based on findings in economic literature.

For **transport** we distinguish impacts from expanded accessibility and from the improvement of road safety. In the former case productivity impacts are estimated for **expansion and rehabilitation** of urban roads, of rural roads, and from expansion of public transport services (BRT and rail networks). These are based on estimated Total Factor Productivity impacts of relative road and rail infrastructure expansion in South Africa by Fedderke and Bogetic (2009).[[1]](#footnote-1) For rural roads the rural access index is used to normalize the additional road network leading to people getting all-weather road access to the major urban centres of South Africa.

Concerning **road safety** the central assumption is that bringing 75% of roads to 3-star rating achieves half of the SDG 3.6 objective for road safety - a reduction in accident-related mortality.[[2]](#footnote-2) The resulting improved adult survival rates are translated to productivity impacts based on Bloom et al (2019), similar to the approach for disease-reducing productivity impacts identified for Water & Sanitation.[[3]](#footnote-3)

For **water and sanitation** two distinct mechanisms for productivity impacts are identified as well. Firstly, **improved access** to safely managed water supply, sanitation, and hand washing hygiene allows to reduce diarrhoea-related disease and mortality. Prüss-Ustün et al. (2014) estimate the total of preventable Water, Sanitation & Hygiene deaths in South Africa. Their estimate translates to 3.8 thousand of these adult diarrhoea-related deaths among people of working age (15-64) in 2020 and a diarrhoea related death rate of 0.096 deaths per thousand persons, and to an increase of 0.57% in adult survival ratio.[[4]](#footnote-4) The increase in adult survival rate leads to a 0.31% higher TFP by 2030 for full achievement of water & sanitation SDG’s in South Africa, based on insights from Bloom et al. (2019), while Universal Basic Service levels would lead to a TFP improvement of 0.22% TFP improvement by 2030.[[5]](#footnote-5)

Secondly, for **reduced demand on freshwater resources & increased water resilience** the key assumption is that reduction of water consumption per capita will allow to avoid structural water shortages. Water shortages would primarily hit agricultural and other productive sectors to spare water supply to citizens. The reference or status quo scenario sees South Africa’s water consumption grow and is expected to lead to an average water deficit of 17%.[[6]](#footnote-6) Based on Ntombele et al (2017)[[7]](#footnote-7). The average structural water shortage is estimated for each scenario based on comparing per capita water consumption levels and this average shortage is equated to a shock pro rata to the economic shock of the 2015/2016 drought.[[8]](#footnote-8) In this way one arrives at a TFP impact by 2030 of: +0.89% for 1BW and 2BW scenarios, and of +0.49% for 2BF vs the No investment Reference.

Concerning **education**, abundant theoretical models about education-driven productivity-wage gaps are not matched by abundance of empirical literature, and evidence for whether education raises productivity and wages is sparse (Kampelman et al, 2018). Nevertheless, Bhorat and Kimani (2017) show that in South Africa educational spending and lower teacher-student-ratios (STRs) lead to higher educational attainment levels. For STRs this would mostly be the case in primary education. Furthermore, a minority of South African pupils enjoys high quality education, while the majority cannot (Spaull, 2013). The conditions therefore seem right for investment in quality of education to contribute not only to better educational levels, but also to an improved economy. However, calibration of such an economic impact remains difficult.

The following approach is applied to estimate productivity gains due to **improvement of basic education**: The Full access and Efficiency scenarios lead to higher enrolment and quality and therefore higher graduation levels for secondary school types relative to the Baseline scenario. A first step quantifies the impact on educational attainment by level of education. [[9]](#footnote-9) Step 2 translates this to a change in school leavers from primary to matric-level educated.[[10]](#footnote-10) Step 3 translates the additional educational attainment in the employed work force to a TFP impact, based on the wage ratio between average secondary educated and primary (or less) educated workers.[[11]](#footnote-11) This leads to an additional TFP growth of additional educational enrolment and quality of 0.22% for the period 2022-2030. The difference relative size of additional capital investment between Baseline and the No investment reference scenario would imply that the TFP impact for the baseline vs the reference scenario is 0.3%, and therefore the TFP impact of Full access and Efficiency scenarios vs Reference are 0.53%.

For **TVET education** the same approach applies: This time the enrolment numbers lead to a shift from learners entering the labour market at the lower-secondary level to the matric/upper-secondary level.[[12]](#footnote-12) Again, based on relative capital expenditure for expansion the impact of the Baseline scenario relative to the Reference scenario is estimated. The result of the estimation is that additional TFP growth for the total period up to 2030 is 0.37% for the NDP scenario, 0.08% for the Baseline scenario, and 0.75% for the PSET scenario.

### Abstract References

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1. We use the estimate by Fedderke and Bogetic (2009) that the TFP elasticity of (the natural logarithm of) the total length of the national road network is 2.8. For Rail (also applied to BRT) Fedderke and Bogetic estimate that the elasticity of the (natural logarithm of) the number of passenger railway journeys to TFP would be 0.159. [↑](#footnote-ref-1)
2. The SDG 3.6 objective for road safety is a reduction in mortality due to road traffic accidents by 50% in 2030. [↑](#footnote-ref-2)
3. their estimate of labour productivity impacts of health-related improvement of adult survival rate is that L-productivity has an elasticity of 1 with the adult survival rate – based on the L-share in VA (53.5% in SAM 2019 data) and estimate the impact of this improved adult survival rate at 0.2%. [↑](#footnote-ref-3)
4. Based on authors own calculations, taking into account the following: Prüss-Ustün et al. (2014, Supplementary Material) estimate the total of preventable Water, Sanitation and Hygiene deaths in South Africa at 6.3 thousand in 2012, or 0.12 deaths per thousand people. In 2020, at the same rate, the number of deaths would amount to 7.2 thousand deaths. Children under 5 years old made up 43% of these deaths in LMIs (361.000 out of 842.000). Assuming low mortality related to diarrhoea in children aged 6-14, the adult mortality in South Africa related to diarrhoea would have amounted to 4.1 thousand deaths in 2020. On a population of 42.6 million persons aged 15 or older this means a diarrhoea related death rate of 0.096 deaths per thousand persons. People of working age (15-64) make up 93% of the adult population, and could therefore represent 3.8 thousand of these adult diarrhoea related deaths in 2020. Average adult mortality stood at an estimated 303 per 1,000 adults under 65 in South Africa. The latter implies that out of 39.6 million working age people in South Africa in 2020 about 12 million will die before the age of 65 – equivalent to on average 0.24 million per year, or 6.06 per thousand working age persons. A decrease of 0.096 deaths per 1,000 persons would thus mean a 1.6% decrease in death rate and thus decrease mortality from 303 per 1,000 to 298 per 1,000 – and increase the adult survival rate from 697 per 1,000 to 702 per 1,000 – an increase of 0.57%. [↑](#footnote-ref-4)
5. With Bloom et al. (2019)’s average elasticity of 1.0 (0.67 to 1.3) of labour productivity to adult survival rate, this would mean a 0.57% increase of labour productivity of achieving the SDG’s for water, sanitation and hygiene in South Africa, relative to 2020. The 2BF and 2BW scenarios see full achievement of the SDGs for Water and Sanitation. This leads to 0.57% higher labour productivity (by 2030). South Africa’s SAM 2019 shows an average labour share in Value Added of 53%. Simplifying matters, the assumption is that the equivalent increase in TFP is 53.5% of the Labour productivity increase from literature, thus arriving at a 0.31% higher TFP by 2030. For the 1BW scenario, the achievement of Universal Basic Service levels are assumed to lead to a 2/3rd reduction of water supply related diarrheal disease burden, and a 1/3rd reduction of sanitation-related disease burden, and 100% of hand washing. Translated to reduced adult mortality the Labour Productivity improvement would be 0.40% by 2030, which I then translate to a 0.22% TFP improvement by 2030. [↑](#footnote-ref-5)
6. See sector report Water & Sanitation, p.24: "3.4 Objective 4: Increased water resilience: … The scarcity of resources and the increase in service levels increases the risk of water shortages during droughts. The NWSMP (DWS, 2018) warns of a 17% water deficit by 2030." [↑](#footnote-ref-6)
7. Ntombele et al (2017) estimated (with a counterfactual CGE model scenario) the impact of the 2015/2016 drought on SA's GDP to have reduced the potential GDP by 1,49% through its impact on agricultural output. The 2015/2016 drought saw rainfed water supply decrease by a third compared to the long-term average, meaning a shortage of 29%. Combining this with the NWSMP implies that current long-term structural natural water supply of South Africa has an average 6% surplus compared to water use. [↑](#footnote-ref-7)
8. Because the reference growth has already been set, the assumption is that the scenarios with less water shortages than the Status Quo scenario see their TFP impact as higher TFP growth than the no investment reference. [↑](#footnote-ref-8)
9. While Full Access and Efficiency scenarios improve educational quality with a different focus, this means that the Efficiency scenario increases upper secondary educational output more before 2030, whereas Full Access spends more on all educational levels, and reaches higher matric graduation levels only later on. Yet, we assume that the labour market impact of full access broad quality impuls would be the same as that of the additionally obtained matric graduations in the Efficiency scenario. [↑](#footnote-ref-9)
10. All students, and not only the additional students thanks to the investments, will benefit from improvements in Student-Teacher- ratios (STRs) and improved facilities, hence we can expect the average learner to enter the labour market with slightly improved skills. To simplify matters the labour productivity impact is concentrated within a group of learners equal in size to the additional amount of learners. We furthermore assume that this only concerns “will-be-employed” school leavers, and that the net effect is that the amount of additional learners in one cohort would move from being a primary/less-educated worker to becoming a secondary/matric-educated worker. [↑](#footnote-ref-10)
11. The wage ratio between upper-secondary educated, and primary or less educated workers would be on average 2.41 for the 2022-2030 reference projection. [↑](#footnote-ref-11)
12. The corresponding wage ratio between upper-secondary educated and lower-secondary educated workers would be on average 1.89 for the 2022-2030 reference projection. [↑](#footnote-ref-12)