Local Government Skills Forecasting model

Skills demand and supply forecasting in South Africa, with focus on water sector

WP-MDS-2

Report prepared for:

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CSIR document reference number:

Groupwise PTA 259974-1

Date:

March 2016

Document to be referenced as:
LG SETA (2015) Skills demand and supply forecasting in South Africa, with focus on water sector.

Date: March 2016

Contract: LG SETA
Workpackage: WP-MDS-2

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1. INTRODUCTION

1.1. BACKGROUND

The Council for Scientific and Industrial Research (CSIR) has been appointed by the Local Government Sector Education and Training Authority (LG SETA) to develop a model to forecast the demand and supply of skills in the local government water sector in South Africa.

This entails the identification and acquisition of relevant data, identification of assumptions and the identification of a prediction framework, or approach, that can be used to estimate and evaluate skills demand and skills supply for South Arica, with focus on water infrastructure at the local government level. Note, the intent of prediction models are to facilitate planning that will be required to ensure that projected skill requirement can be met – and as such, the intent of the proposed model here, like any prediction model, is to be useful in decision making. In this context, we quote from ILO (2008) that "*there is no single model of an effective national response to the challenge of upgrading skills development and bridging skills gaps*", rather that the objective has to be that such prediction help in improving the management of skills planning as a resource.

1.2. PURPOSE OF THIS WORKPACKAGE REPORT

The purpose of this workpackage report is to consolidate information related to skills forecasting that have previously been done, or are in practice, specifically for the South African context. The purpose is also to see whether such are applicable *as is* to the purpose of skills forecasting needs specifically for the water infrastructure sector at the local government level.

This report will also propose some statistical modeling approaches for the data that was collected as part of this project by the CSIR.

1.3. SCOPE OF THIS WORKPACKAGE

The scope of this workpackage is limited to publicly available information such as the internet, publications, relevant engagements the team has had, as well as specific

interaction with experts in the water sector and/or in the area of empirical forecasting techniques, as well as general modelling capability that resides within the group.

2. RELEVANCE OF THIS WORKPACKAGE TO THE NATIONAL SKILLS DEMAND STRATEGY III

In the Department of Higher Education and Training (DHET) National Skills Development Strategy (NSDS) III document of 2011 Minister Nzimande highlights that there is a need to '*address the challenges - of skills shortages and mismatches - we face as a country and improve productivity in the economy. … Central to the objectives of the NSDS III is improved placement of both students and graduates, especially from the FET colleges and universities of technology.*' The NSDS III sets guidelines for sector specific skills planning within the framework of the SETAs. Quoting from the report: "*There is currently no institutional mechanism that provides credible information and analysis with regard to the supply and demand for skills. While there are a number of disparate information databases and research initiatives, there is no standardised framework for determining skills supply, shortages and vacancies, and there is no integrated information system for skills supply and demand across government*." The previous NSDS I and NSDS II emphasized that instead of setting national level targets for skills, there is a need for each sector to define the skills sets they need and at which levels they are needed in order to meet the demands of that sector and the corresponding SETA.

What the NSDS III implicitly entails is that each sector has its own profile of skills demands not only because of the specific service it provides, but also with regards the spatial and demographic specifics it serves given certain technologies in place. To ensure that the service provided by a specific sector is served optimally, it is thus essential to understand which skills – both with regards quality (number) and quality (level) are necessary. As such, a first step towards this is to understand a sector in detail in conjunction with the skills they have, and where shortfalls, if any, exist. Thereafter, it is essential to understand future trends in the demands on that specific sector to inform the modelling of skill demand forecast. Note, this in turn will inform what institutional arrangements need to be in place to ensure that such skill demands are met, which is the supply side of the forecasting exercise. The NSDS III further mentions that in the event that some skills – critical, scarce or otherwise – are not

available within the country, a system has to be in place to meet such demands from outside the country. To avoid meeting skills demands through sourcing from outside the country, and to ensure that more people are skilled and employable within the country, informed planning is thus essential.

3. SKILLS FORECASTING FOR SOUTH AFRICA

In this section we present an overview of some relevant literature on skills forecasting that have been undertaken for South Africa.

3.1. The HSRC-Warwick Institute for Employment Research project

The Warwick Institute for Employment Research (WIER) of the United Kingdom (UK) along with the Human Sciences Research Council (HSRC) in South Africa undertook a project in 2004 that was commissioned by the Department of Labour "… *to investigate the feasibility of developing quantitative forecasting models to help identify future skills needs in South Africa*." They also noted there was sufficient multi-sectoral macroeconomic modelling capability within the country that could be contribute to the input side of the skill forecasting exercise such as in partial-equilibrium modelling, and Computable General equilibrium (CGE) modeling that is based on a Social Accounting Matrix (SAM). However, for skills forecasting specifically, they presented a discussion on the challenges with some of the approaches, which they also summarized in a table, that we also present below:

Table 1: Comparison of the Pros and Cons of Alternative Approaches to Anticipating Skill Requirements

Alternative approaches	Advantages	Disadvantages
Formal, national level, quantitative, model based projections	Comprehensive Consistent Transparent Quantitative	Data hungry Costly Not everything can be quantified May give a misleading impression of precision
Ad hoc sectoral or occupational studies (using a variety of quantitative (model based) and qualitative tools)	Strong on sectoral specifics	Partial Can be inconsistent across sectors
Surveys of employers or other groups, asking about skill deficiencies and skill gaps	Direct "user/customer" involvement	May be very subjective Inconsistent Can too easily focus on the margins (i.e. current vacancies) rather than skill gaps within the current workforce
Focus groups/round tables and other Delphi style methods	Holistic Direct "user/customer" involvement	Non-systematic Can be inconsistent Can be subjective

Source: Wilson *et al* (2004) page 12.

Wilson et al (2004) recommend a four-module approach to skills forecasting for South Africa, that include a 'multi-sector macroeconomic model'; a 'occupational model'; a 'replacement model' for attrition; and a 'qualification model'. Although they concluded that there were adequate skills in the country with regards to multi-sector forecasting, concern was raised about availability and quality of relevant data for developing a skills model for South Africa. Wilson et al (2004) did not recommend collection of additional primary data such as data obtained from questionnaire surveys. Note this project was also prior to the availability of the 2011 recommendation in the NSDS III in which sector specific skills forecasting was recommended.

Wilson el al (2004) discuss Barker (1999) in which it was highlighted that even though a large number of individual decisions influence skills choices and movements in an open economy, skills forecasts are none-the-less useful in guiding investments in the sector and education.

Wilson et al (2004) then discuss the Bureau of Market Research 2001 report which focused on skills shortages at that time, and was a combination of both qualitative and quantitative information. The forecast were at the national level and interestingly, at that time, the conclusions of the study were "… the South African higher education sector needs to produce more IT specialists, electronic engineers and specialist managers. The study also argued that the educational system needs to be more closely aligned to the needs of employers, i.e. greater emphasis should be placed on teaching the specific skills that industry requires."

Wilson et al (2004) also summarised three of the studies undertaken by SETA in conjunction with the HSRC specifically for the Financial and Accounting Services (FASSET), the Chemical Industries Education and Training Authority (CHIETA) and the Forest Industries Sector Education and Training Authority (FISETA). These studies were based on surveys that were not of adequate quality, and once again recommendations were at the national level.

3.2. The Human Science Research Council projects of 1999 and 2003

Whiteford et al (1998) presented a study conducted by the HSRC in which they focused on eight economic sectors excluding agriculture, and projected trends for the labour

market over the period 1998-2003. Although the forecasts were at the sectoral level, they were not available at the lower spatial resolution such as a municipality level.

The 2003 study was reported in Woolard et al (2003) and extended the 1999 study with focus on scarce skills. The projections, which were based on a combination of exogenous sectoral forecast and occupation demand forecasts, were by sector, and the 'plausibility' of the projections was validated by discussing with experts. However, as in their previous report, all projections were at the national aggregate level.

3.3. Labour Market Intelligence Partnership (LMIP) Working Paper

The Chitiga-Mabugu and Ngandu (2012) paper discusses national skills forecasting models as analytical models and policy models. They further discuss at length the challenges of such forecasting in South Africa, particularly with respect to data availability.

3.4. Umhlaba Skills Service study

National Skills Authority-Briefing Paper (2007) was the result of a joint work done by Umhlaba Skills Service (USS) together with German Technical Co-operation (GTZ) with specific focus on scarce and critical skills. USS also did a study for the Manufacturing, Engineering and Related Services Sector Education and Training Authority (MERSETA) to enable long-term skills need in the automotive sector (Umhlaba, 2006). However, these studies were for a specific purpose.

3.5. Linked Macro-Education Model (LM-EM)

In 2013, a skills forecasting model, named the Linked Macro-Education Model (LM-EM), was presented to the DHET. LM-EM was developed jointly by the Applied Development Research Solutions (ADRS), Labour Market Intelligence Partnership (LMIP) and the Center for Researching Education and Labour (REAL) at the University of the Witwatersrand. As the name suggests, the model aims to capture the link between macro-economic projections and education. The aim of the model and the associated interactive online interface intends to enable scenario based projections for skills. The skills are categorized into sectors as well as demographics. Details are available in Azghar (2015). This model and associated interactive tool, to our

understanding, is limited to national level skills demand projections, and not for the purpose of the local government planning.

3.6. SCOPE AND LIMITATIONS OF THE ABOVE APPROACHES

As aforementioned, each of the skills forecasting approaches or models mentioned above have a top-down vision, with focus on skills demand forecast at the national level. While some approaches have disaggregated the national level skills forecasts into sectors, a limitation of the approaches is that the forecasts are not useful for municipal level, or even provincial level planning. Further, the approaches focus more on the macro-economic aspect, rather than at regional level specifics that take into account regional challenges and constraints. While the limitations are due primarily to the data that is available, they are less useful for investing in planning at the local government level with regards skills forecasting, which is the intent of this project. Further, as discussed in the European Centre for the Development of Vocational Training (CEDEFOP) 2009 publication, one needs to incorporate effect of political and behavioral aspects by obtaining local sectoral information such as via survey questionnaires or interviews, along with economic aspects, into a skills forecasting models. Further, the CEDEFOP (2009) publication flags that aggregate forecasts may defeat the purpose of policies for skills development and associated education and training planning.

In light of the above, our approach will be a bottom-up one in which we will aim to develop skills forecasting model based on primary data that has been collected by the CSIR during 2015-16 in which various categories of water infrastructure were surveyed across the country. Based on the wealth of information collected, the aim is the develop a prediction model for skills types, such as proportion of skills types within the skills types, that are required to operate specific types of water infrastructure. In conjunction with the demographic and economic information of the catchment area the water infrastructure serves, one can then use the skills prediction model to enable scenario based skills forecasting analysis, and the aim is to develop a model that has the ability to incorporate both quantitative and qualitative information.

4. LEARNINGS FROM INTERACTIONS WITH EXPERTS IN THE WATER SECTOR AND/OR SKILLS FORECASTING

During the project, we were fortunate to engage with individuals who have experience with skills aspect in the water sector. To that effect, we engaged with Abri Vermeulen who is a Professional Engineer (Civil) working in the area of Water Governance and Planning – Africa at AECOM. Vermeulen shared with us his experience in working with various municipalities specifically in the water sector how there are some of the municipalities that function well and others that do not, and the need to gather in detail the skills available and skills gaps in different water infrastructure to enable an informed skills forecasting exercise.

Although we did not meet with Adriane Bird of the DHET specifically as part of this project, we are aware of her work as part of previous projects related to skills planning

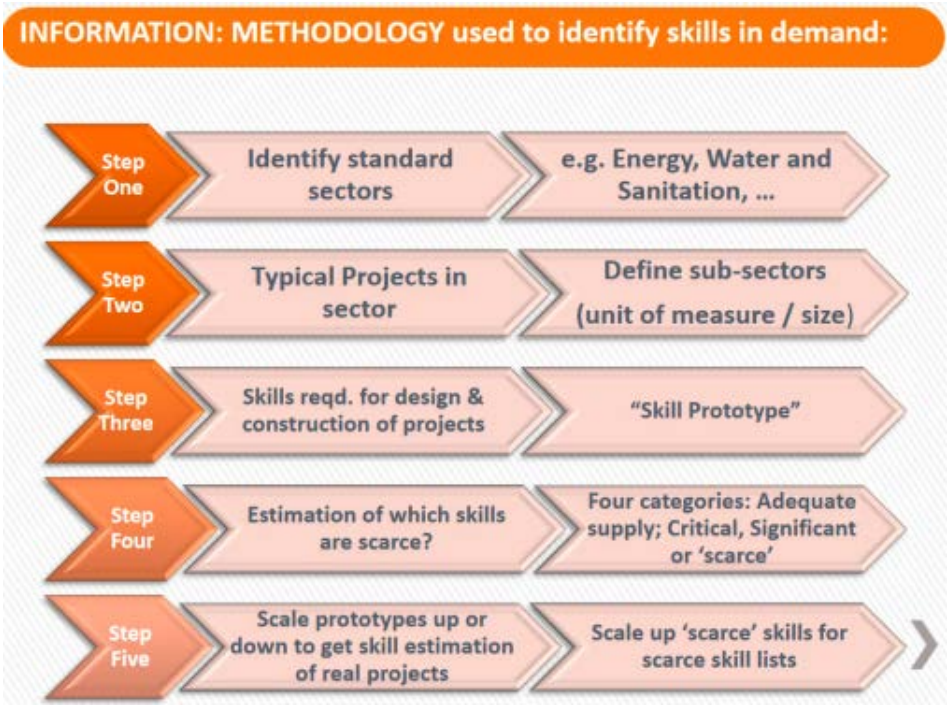

Figure 1: Source: https://www.ecsa.co.za/news/News%20Articles/091013_ECSA_Skills_Research_Launch_DHET.pdf

for Strategic Integrated Projects (SIPs) that include infrastructure projects that are the basis of growth. Bird details the need to have information on occupations that are in demand, then the need to inform DHET institutions accordingly, the need to engage with SETAs, and of course, monitoring and evaluation of the process. Bird was also in-charge of the '*Skills for SIPs and the importance of research*' that details the need for alignment of the SIPS projects to the National Development Plan, and highlights that building skills are as integral as building physical assets. Schema of the methodology proposed in the report is presented in Figure 1.

We also had the opportunity to engage with Dr Azghar Adelzadeh by inviting him to the CSIR to ask him more about the history of the development of the LM-EM model, its scope and limitations. Members of the project team also attended the inaugural workshop of the LM-EM tool, as well as a 2-day workshop that followed to get acquainted with the scope and limitation of the tool.

5. PROPOSED MODELLING FRAMEWORK

Our intent in the project is to develop a model on the basis of available data, that includes the survey data collected by CSIR as part of this project, and complementary data from other official sources such as the Stats SA, that will help in the planning for skills, both demand and supply, in water infrastructure at the local government level better. To that effect, there are inherently two sides to this modelling: the demand side forecast and the supply side forecast. In the skills demand side forecasting, as explained in **Error! Reference source not found.**, one first needs to understand how the characteristics of the water infrastructure maps to the existing skills types (**Error! Reference source not found.**, first blue oval). Further, each water infrastructure serves a certain area with its own usage, population and economic activity profile. In the event one can obtain how the specific area will grow in terms of say usage, population and economic activity in the future (**Error! Reference source not found.**, second blue oval), one can the estimate the number of the various skills types required if the same service level is to be maintained.

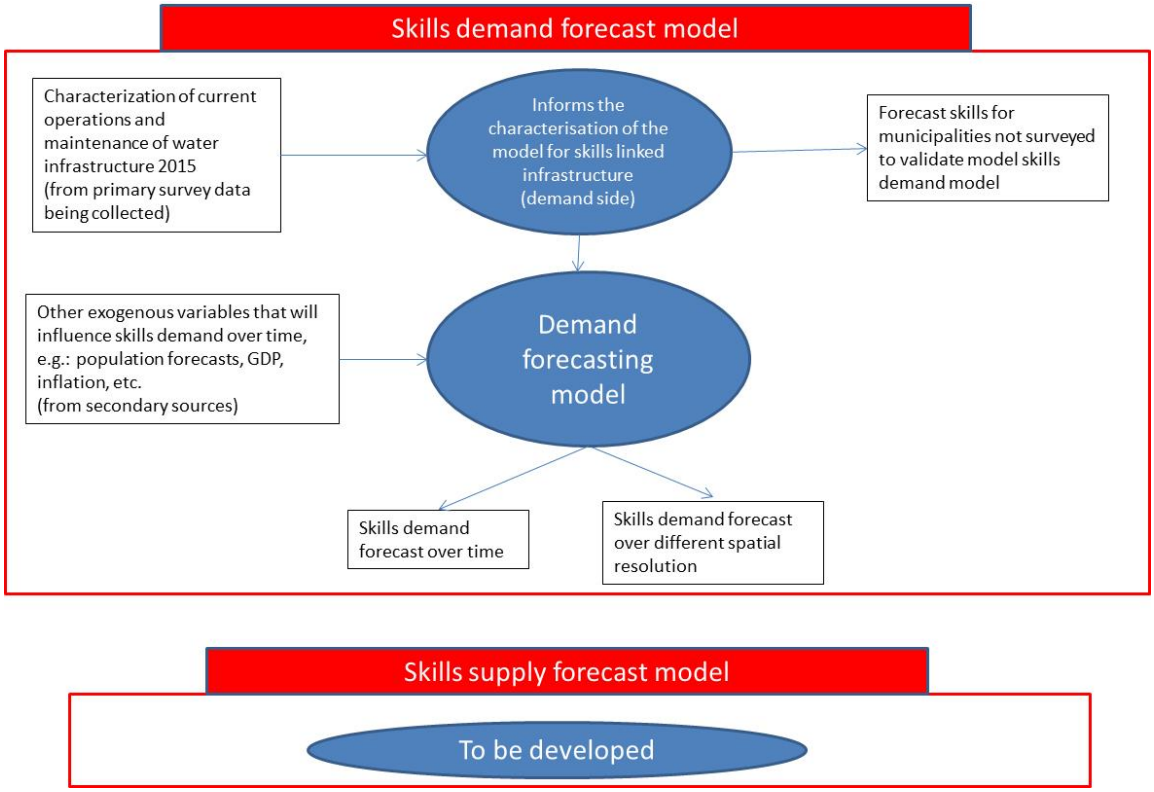

Figure 2: Schema for the development of a skills forecasting model.

On the skills supply side forecasting, the process is, to our understanding, and based on the NSDS III report as well, more a management exercise where by the outputs from the skill demand forecasting models can be used to influence tertiary education institutions to accept more student in specific areas where a future demand is anticipated. However, we will explore more literature to help with this process as well.
In this report, we will elaborate on the modelling framework for skills demand forecasting as a two phase exercise:

5.1. PREDICTION MODEL PHASE:

A prediction model is a statistical model that aims to capture the relationship

between *responses* of interest in terms of certain *predictor* variables mathematically. The response of interest then are the *dependent* variables, while the predictor variables are the *independent* variables in the model. A

regression model which links the dependent variable with the independent variables then allows us to explore the behaviors of the dependent variable in terms of the independent variables. Depending on the type of the dependent variable, such as univariate versus multivariate, or continuous versus count, to name a few, various types of regression models can be estimated.

Once model parameters have been estimated based on whichever assumption that are assumed, one can then plug new values for the independent variables and obtain a predicted value for the response of interest. Since the data from which the model parameters are estimated only represent a sample of the population and because the mathematical relationship estimated is only a representation of the underlying data generating process (DGP, predictions from the models are provided with a level of confidence around them.

Any prediction model thus has three major components to its development:

- Data: Since any statistical model will use the data to estimate the parameters, the quality of the data will reflect the usefulness of the estimated parameters for prediction for new values of the independent variables. Further, for the parameters to be estimable, it is necessary of the sample size to be larger than the number of parameters to be estimated in the proposed model.

- Assumption: As mentioned above, since the aim is to capture the relationship between the response of interest in terms of a set of independent variables, a number of assumptions are made, which may influence the value of the predictions one makes using the model.

- Statistical model: As highlighted above, since the underlying DGP is inherently unknown to the modeller, the statistical model one estimates will influence the prediction.

For the LG SETA skills demand prediction phase, the aim is to be able to estimate a prediction model that maps the features of each of the water infrastructure to the outcome of interest -- that is skills types. In our approach, suppose we are interested in one particular skills category, say “Process Controller 1”, then any particular person employed in that facility either belongs to the category “Process

Controller 1" or not, which is a Binomial framework. From the data that has been collected by CSIR from the surveys, one can then identify those water infrastructure that are known to perform well, and their facility features and financial indicators for the regression component of the model. Thereafter, one can assume very unrestrictive priors on the proportion *p* of "Process Controller 1" that is of interest, and obtain the estimates of *p* and its posterior distribution using the Beta-binomial GLM framework. The reader is referred to an application of the Bayesian binomial regression, for purely an illustrative purpose, to the work of Bedrick et al (1997) in which the application problem was to understand the trauma scores using in a fully Bayesian approach for a binomial regression problem by incorporating priors that were elicited from experts. As such, a proposed framework is Bayesian prediction approach which allows for the incorporation of both the qualitative a well as the quantitative information of the problem.

For the LG SETA skills demand prediction phase, the aim is to be able to estimate a prediction model that maps the features of each of the water infrastructure to the outcome of interest -- that is skills types. In our approach, suppose we are interested in one particular skills category, say "Process Controller 1", then any particular person employed in that facility either belongs to the category "Process Controller 1" or not. Immediately, this is now a Binomial framework. From the data that has been collected by CSIR from the surveys, one can then identify those water infrastructure that are known to perform well, and their facility features and financial indicators for the regression component of the model. Thereafter, one can assume very unrestrictive priors on the proportion *p* of "Process Controller 1" that is of interest, and obtain the estimates of *p* and its posterior distribution using the Beta-binomial GLM framework. The reader is referred to an application of the Bayesian binomial regression, for purely an illustrative purpose, to the work of Bedrick et al (1997) in which the application problem was to understand the trauma scores using in a fully Bayesian approach for a binomial regression problem by incorporating priors that were elicited from experts.

The benefit of pursuing the Bayesian binomial regression approach then is that, for those water infrastructure which are known to under-perform, one can use their corresponding set of independent variables of facility features and financial indicators to get predicted proportion from the model based on those that perform well. Thereafter, one can compare the predicted proportion for 'Process Controller

1' for the under-performing water infrastructure with its actual proportion for 'Process Controller 1'. In case of significant difference between the two proportions, that is the proportion predicted by the model based on good performing water infrastructure versus the actual proportion of the under-performing water infrastructure, one can get an idea on whether the under-performing water infrastructure can improve on its service delivery if they increase or decrease the number of 'Process Controller 1' type of employees. Similarly, one can extend this analysis by considering a multinomial setup where one is interested to predict more than one types of skills demand together.

It is important to remind the reader at this stage that the data that was collected by the CSIR team via the questionnaire and interviews was aimed to capture in as much detail as was possible the skills profile that exists or those that are vacant for the particular water infrastructure. The intention is then to use the data and apply a Bayesian framework to enable the investigation on the proportion of various skills types and get an insight on what may need to be changed in order to improve service delivery by changing the skill proportion. It will also be a learning process, and may be an iterative model development exercise.

5.2. FORECASTING MODEL PHASE:

Forecasting models are similar in principle to the prediction model with the inclusion of a time aspect to the model. A common forecasting model would be a time-series model where the evolution of the response variable over time is of interest, with the response variables having a time-ordering aspect. One can include other independent variables in the model as in the prediction model in the form of a time-series regression framework.

In our case however, since we do not have a time-series of skills from the water infrastructure at the LG level, our initial focus will be on obtaining independent forecasts of the drivers of water demand such as, *inter alia*, population growth forecasts, economic growth forecasts, industrial growth forecasts, agricultural growth forecasts, technology change forecasts for a specific time horizon. This should ideally be available at the level of LG resolution, which for our purpose would be at the municipality level. Such forecasts may be obtained from the StatsSA, academic outputs, expert knowledge, and the like. These will then inform

the corresponding demand on the water infrastructure itself, as well on the skills profile numbers. For instance, if the forecast is that additional X'000 people need to be served after T years, and everything else remains unchanged, and the recommendation is the establishment of a new water infrastructure, then one can estimate how much skills and of what type needs to be available in that period to operate the new water infrastructure 'best'. Thus, given existing technologies currently used, using the prediction model, one can ascertain skills capacity specifications of such a water infrastructure for the forecasted demand. One can then inform the skills educators, that is the tertiary institutions as well as the Technical Vocational Education and Training (TVETS) to prepare/ train such number of students/ learners in that period.

Further, there are a number of scenarios related to skills demand forecasting such as forecasting based on assuming that existing technologies remain (business as usual scenario), adaptation/ upgrading existing skills set to respond to previously unseen technologies; and finally, replacing skills that leave the skills pool one of the following reasons: promotions/ resignations/ retirement/ death.

Surveys to perform skills audit can inform the current status and gaps in skills type and numbers to operate and maintain existing water infrastructure. One can use such information to draw the relationship between water service demand and the combination of existing technologies and skills.

For skills demand forecast in the event of 'new' technologies coming into use, our understanding is that when new technologies in any field come into existence, such are introduced into the curriculum that fresh graduate students see as part of their course work at the Technical Vocational Education and Training (TVET) of tertiary education centres. As such, along with existing personnel who have more practical experience and knowledge of running a facility, these fresh graduates can bring in the competencies required to adapt the facility to the challenges of new technologies.

Compared to forecasting skills demand, forecasting skills supply is more challenging as it depends on, *inter alia*, population growth, the qualification granting mechanism in place – and also the input from the preceding qualification institution (basic education), alternative job opportunities. The ease of spatial access to

opportunities may result in pupils to attending local institutions, rather than because there is a potential demand of certain qualifications. Also pupils can be making choices informed from a variety of reasons, including, but not limited to, job availability for that discipline and eventual salary, difficulty of the subject, cost associated with that qualification, growth, etc (NSDS III, page 22).

While the demand side of skills forecasting has been discussed in different research outputs, there is a paucity of similar literature on supply side skills forecasting. However, from our deliberations we understand that a serious contribution to the success of adequate supply of required skills is the pre-preparation lag time and institutional infrastructure and training staff/ faculty that need to be in place to be able to respond to the demand at a certain period in time in the future. For instance, for qualifications that need say 5 years to acquire, the institutional components should be in place at least 5 years prior to that. Prudent and regular planning and coordination between education departments as well as the demand side departments is absolutely essential for the success of the supply side of skills. Therefore, it is crucial that the concerned departments meet routinely to understand, to prepare and to make budgetary provisions for delivering on the demand of certain skills as forecasted. This has also been highlighted in the NSDS III (page 11). If such is not the case, then it is very likely that the supply side of skills demand fail to align with the demand side forecast of the skills, which ultimately will result in failure of the state to provide appropriate and timeous service delivery in any sector, including the water sector at the local government level.

A caveat that needs to be made is that for both demand and supply forecasting, there are possibilities to forecast false positives – that is predicting for skills that are not necessary; as well as false negatives – that is failing to predict for required skills. The ‘goodness’ of the skills forecast model, like any other model, will depend on the associated data available and assumptions made. There is also the need to make provision for validation of the forecast models, and re-estimation of the forecast as additional data is obtained from more recent surveys.

6. FORECASTING SKILLS DEMAND AND SUPPLY IN THE WATER SECTOR: LEARNINGS FROM CSIR SURVEY

As mentioned earlier, forecasting for sector-wise demand and supply of skills at the sub-national level, such as at the LG level, requires an understanding of how various sector LGs operate, and what kind of technologies they use and what the corresponding skills need are. Restricting to only national level data as the basis for sectoral forecasts at the LG level will be limiting in its usefulness.

As such, the extensive survey conducted by the CSIR to understand the status quo of water infrastructure in different municipality types across the country, along with the skills profile employed, and gaps thereof, is a core component to develop the linkages between the demand pull and supply push sides of water and sanitation services. These surveys provide the opportunity for mapping of the serviced population with the infrastructure capacity and technology, incorporating the spatial distribution of the beneficiaries. Further, it allows to map the infrastructure with the staffing structure that relate to the tasks performed using certain combination of skills and qualifications.

It is also a challenge for the forecasting exercise that some water infrastructure operates at a water board level, while others operate at a municipal level. While our aim is to enable forecasting at the municipal level since other relevant data are more readily available at that level, rather than at the water board level, methods to aggregate or disaggregate the survey data as necessary to make municipal level forecasting possible is an exercise that may be needed. The CSIR has experts who can help with such prior to the forecasting stage. Similarly, projections for exogenous inputs for scenario analysis, such as inclusion of changes in socio-economic and technological horizons, can be aligned to enable municipal level analysis.

7. CONCLUDING REMARKS

The purpose of this report was to set the stage for developing the model for skills demand and supply forecasting at the local government level for specifically for the water sector. To that end, a review was carried out on information available online on previous studies done in this regard. What emerged as common in them was

that they were all developed for the purpose national level forecasts. However, as mentioned already, caveats have been raised that national level modelling based purely on economic factors, without taking into account regional factors, may defeat the purpose of planning for skills at local government level.

In our case, the objective is to inform LG SETA about skills demand and supply for the water sector. To that end, primary data that was gathered from water infrastructures from across the country holds important information that can be modelled for the specific purpose of this project. This is a bottoms-up approach to the forecasting exercise, rather than forecasts that are made at the national level based primarily on macroeconomic inputs. Note also that macroeconomic data are available historically, but sector specific data are generally not available historically. As such, we would like to propose the development of a skills forecasting model that focuses on the water sector at the LG level that has a mechanism to include qualitative information from the surveys along with expert qualitative information.

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