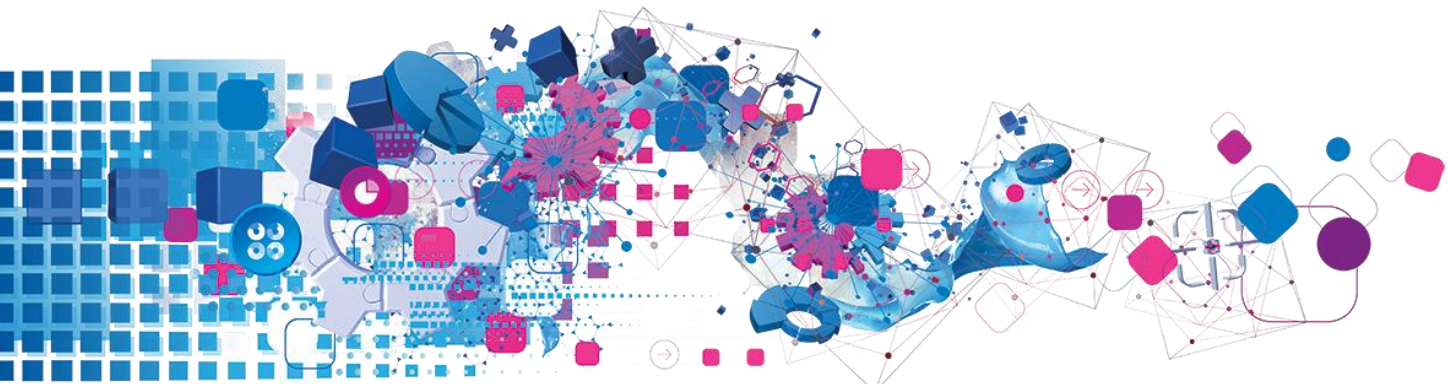
Non-household water demand forecasts: South West Water

January 2022



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1. Model Development

1.1 Data Sources

In order to develop the non-household water demand forecasting model, a set of historical water demand data from South West Water is required. For this purpose, South West Water provided account level data for non-household customers between 2007/08 – 2020/21. Due to 2020/21 being an exceptional year, it was not used to create the models. The data consisted of individual customer records showing water demand for each billing period (financial year). For each account, Experian received the following information:

- Unique ID
- WRZ
- Water usage (Ml/day)
- Industry
- Read date

Other data sources include:

- Experian's forecasts: the macroeconomic and regional level economic forecasts produced by Experian's Economics Team.
    - Output – Gross Value Added (GVA)
    - Employment – Workforce jobs (WFJ) or Full-time equivalent (FTE) employees
- The Office for National Statistics (ONS): 2011-2020 mid-year population estimates OA

1.2 Data cleansing process

Experian undertook the considerable task of processing this data to produce a consistent time-series of water demand. Appropriate techniques have been applied to the dataset to ensure data quality is consistent; the process has seen removal of duplicate records. In addition, Experian aggregated the detailed sectors into appropriate industry grouping with similar economic characteristics to increase the robustness of the data.

1.3 Economic forecasts

Experian's standard UK Regional Planning Service (RPS) provides detailed data and forecasts for the UK regions, their constituent counties and local authority districts for the period 1997-2041. The headline indicators of GVA and employment are provided for 38 industry sectors which draw on official datasets and Experian's own proprietary data. To ensure all our forecasts are consistent, Experian uses a 'top-down' approach, in that the global macro view is set first. The global macro scenario is then filtered down to the regions and cities via Experian's in-house regional models. The drivers of regional and city-level economic activity and employment are the following:

- National performance – incorporates specific structural factors which effect all regions
- Demographics – particularly growth/decline in the working-age population
- Industrial structure – Do regions have high/low concentrations in strongly/weakly performing industries?

1.3.1 Output and employment forecasts for the South West Water supply area

Experian's standard forecasts at local authority level extend to 2041, which for the purposes of this project were trended out to 2080, providing a 60-year forecast horizon. South West Water's water resource zones do not follow standard administrative boundaries, so estimates of economic variables are based on employment estimates at middle super output areas. These were then aggregated to create a time series for the South West Water supply area.

1.4 Model specification

We reviewed the accuracy of non-household water consumption forecasts produced for WRMP19 compared with the latest recorded volumes of water consumption. This task enabled us to assess the overall accuracy of previous forecasts and gain an understanding of how different elements of the forecast model performed.

Going beyond a simple trend-based analysis of historic variables, the model construction considers economic theory to identify variables which can be used to forecast future water demand. Water is demanded by industry because it is an important input into the productive process. Therefore, the first step was to group the Wessex Water sectors into four broad industry sectors: Agriculture, Services, Non-Services and Public, which is outlined in Appendix A. Unclassified sectors are also included in the analysis, which is dealt with separately. Depending on the industry in question, water may be used directly in production as a raw material. Alternatively, water may be used indirectly such that it is consumed by people in the working environment. Accordingly, the following variables were found to vary the NHWD:

- **Gross Value Added (GVA):** GVA and water demand is expected to have a positive relationship. This means when output for a sector increases water consumption, represented as an input, will also increase.
- **Full-time equivalent employment / Work force Jobs (FTE/WFJ):** Employment and water consumption is expected to have a positive relationship. As the number of people employed increases water, representing indirect use that is consumed by people in the working environment, will also increase. In addition, we can assume that as the number of employees increases, output will rise and represented as an input, so will water consumption.
- **Time trends**: Some broad sectors showed a decline in non-household water consumption that could not be easily explained through other economic factors. Potential explanations include the impact of increasing water efficiency and the aggregate impact of other factors that are not in themselves statistically significant. The time trend variable is therefore used to assume there is some permanent deterministic pattern across time. For instance, if the coefficient of using the actual year (e.g. 2002 = financial year 2001/02) is positive this means water consumption demand increases overtime.

1.5 Initial Model

The four sectors outlined in 1.4 were tested to see if they had a direct relationship with Experian's economic variables for the corresponding sectors. Water consumption, GVA (Gross Value Added) and employment (WFJ/FTE) have been transformed into logarithm form to represent elasticity for an additional unit of input.

$$NHWD_{i_t} = \alpha_1 + \alpha_2\left(GVA_{i_t}/WFJ_{i_t}/FTE_{i_t}\right)$$

- Where NHWD = measured non-household water demand (Ml/day)
- GVA = Total output in non-services sector (Gross Value Added in 2008 prices)
- FTE = Full-time equivalent employment in the agricultural sector
- WFJ= Work Force Jobs in the services sector
- Subscript t refers to time period (2007/08 to 2019/20)
- Subscript i refers to the sector

The model tested is shown above and the results are displayed in the figure 1.6

Even though there are multiple statistically significant relationships, all the attempts for services, agriculture and the public sector have had to be rejected. The magnitude of coefficients does not make intuitive sense for these sectors as it states that the non-household water use for the sectors declines when output value/employment for the sector increases, the equations were therefore rejected. Using this method, did create a viable model for the non-services sector due to the positive sign of the coefficient.

1.6 Results from the Initial Model

Figure 1.6 Coefficients from the model outlined in 1.5

Sectors	GVA	FTE	WFJ
Agriculture	-0.8740	0.04761	-0.9368
Services	-1.2885	-1.4092	-1.2063
Non-Services	2.4468	3.037	3.266
Public Sector	-1.139	-1.4276	-1.918

2. Methodology

The final methodology adopted is detailed in this section.

The approach above did not work for the majority of sectors and so it was adapted to a final model which includes a linear trend. The implementation of this trend was based on the knowledge of water efficiencies improving and causing a fall in water consumption level in the history. This trend was also included in the non-services model for the reason just mentioned and to keep consistency between the models. Water consumption, GVA (Gross Value Added) and employment have been transformed into logarithm form to represent elasticity for an additional unit of input. In the agricultural model, discrepancies in the consumption data were seen in 2016-17 and 2018-19 and this was compensated for in the model with the use of two separate dummy variables.

$$NHWD_{i_t} = \alpha_1 + \alpha_2\left(GVA_{i_t}/WFJ_{i_t}/FTE_{i_t}\right) + \alpha_3 Trend_t + 16/17_{i_t} + 18/19_{i_t}$$

- Where NHWD = measured non-household water demand (Ml/day)
- GVA = Total output in non-services sector (Gross Value Added in 2008 prices)
- FTE = Full-time equivalent employment in the agricultural sector
- WFJ= Work Force Jobs in the services sector
- Trend = A linear trend
- Subscript t refers to time period (2007/08 to 2019/20)
- Subscript i refers to the sector
- 16/17 and 18/19 indicate the two dummies used in the agricultural sector.

The details of each equation can be found in figure 2.1.

Additionally, for the non-services and service sector data from 2019-20 skewed results, likely due to the effects of the pandemic. Therefore, it was decided to remove this year of data when modelling for those two sectors.

The equation for the public sector did not produce results which are intuitively correct. Therefore, it was decided to use trend base analysis which involves examining historical water demand to extract average annual growth rates over an appropriate period for this particular sector. It is important to reiterate at this stage that among the detailed industry level NHWD figures provided by South West Water, there were a number of commercial customers that could not be directly aligned to a sector. This meant that a part of NHWD could not be attributed to a sector and this unclassified data was forecasted by using a similar trend-based analysis that was used for the public sector.

2.1.1 Results and Assumptions for Sector Forecasts

The results of the detailed sector regressions are detailed in Figure 2.1 below:

Figure 2.1: Model coefficients by Sectors

Sector	Constant	GVA/FTE/WFJ	Trend	16/17 dummy	18/19 dummy
Agriculture	94.445326	0.516720	-0.040835	0.125302	0.156906
Services	79.31802	1.40339	-0.04021	n/a	n/a
Non-Services	-22.57340	3.40873	-0.01942	n/a	n/a

2.1.2 Bournemouth Water Forecasts

Due to discrepancies in the data pre and post 2017, Bournemouth data could not be split into 4 separate sectors. Therefore, it was divided into 3:

- Agriculture
- Services and Non-services combined
- Public Sector

Using these three sectors, the same models as above were tried. Therefore, each sector was tested to see if it had a significant relationship with one of GVA, FTE and WFJ. There were no statistically significant relationships, apart from between WFJs and agriculture water demand. The equation for agriculture sector yielded a coefficient of -0.66 for WFJ, which is not intuitively correct. The agriculture equation suggests that water usage declines as employment increases, the equation was therefore rejected.

Thus, to ensure that the model was significant and made intuitive sense, the final forecast was created by modelling Bournemouth Water as a whole. In 2017, there was a change in the reporting method and thus a dummy variable for consumption in 2016/2017 is included to account for this. Again, water demand and FTE are converted into logarithm form to represent elasticity for an additional unit of input. Leaving the final model as:

$$NHWD_t = \alpha_1 + \alpha_2(FTE_t) + \alpha_3 Trend_t + 16/17_t$$

- Where NHWD = measured non-household water demand (Ml/day)
- FTE = Full-time equivalent employment in the Bournemouth WRZ region
- Trend = A linear trend
- Subscript t refers to time period (2007/08 to 2019/20)
- 16/17 indicates the dummy that is explained above

WFJ and GVA were tried but the models did not fit as well as when FTE was used. FTE led to the best fitting model when accounting for statistical outputs (r2 and p-values). The results of the model are displayed in figure 2.1.2.

Figure 2.1.2: Bournemouth Water model coefficients

Sector	Constant	FTE	Trend	16/17 dummy
Bournemouth Water	40.974340	1.288081	-0.020166	-0.178376

2.1.3 Water Resource Zone Forecasts

The final stage of the forecast process was to provide non-household water demand forecasts for each of the three Water Resource Zone (WRZ) areas. The method used was to allocate water demand forecasts across the WRZs using the WRZs share of economic activity in that sector. Using this approach means that water demand in a WRZ will be driven by the economic prospects in the years ahead in each WRZ area. For each WRZ estimates of economic variables are based on employment estimates at middle super output areas. The coefficients from the models used for the whole of SWW were used to find fitted values for each sector in the different WRZs using economic data from each WRZ. The forecasts were constrained so that consumption growth matched that of the whole South West Water area.

$$WC_Z = \sum_i WC_{z_i}$$

- WC is the water consumption level
- Subscript z represents the water resource zone.
- Subscript i represents the sector

3. Summary Results

3.1 Agriculture water demand

Water demand in the agriculture sector has been declining since 2007/08 due to improvement in water efficiencies. This trend is predicted to continue with consumption set to decrease by 16.1% between 2019-20 and 2079-80. However, the first three years account for a swift drop in consumption before it is expected to decline by 0.05% per year on average.

3.2 Services water demand

It is a similar story for the service sector as for the agriculture sector, however the downward time trend is not as strong in the services sector and thus water consumption is set to rise from 2021-22. After the pandemic reduced water consumption, it is expected to rise more quickly from 2021-22 to 2023-24 before growth rates slow down. Growth between 2024-25 and 2079-80 is expected to average 0.2% per year.

3.3 Non-Services water demand

The non-services sector water consumption pattern is very varied, and it sees a large pandemic induced drop off. However, GVA has much more impact on the water consumption than the trend and thus water consumption will bounce back quickly from 2021 to 2023 before increasing at a steady rate of 0.15% on average, per year.

3.4 Public Sector water demand

Due to the reasons stated above, the water consumption forecast was based on trend-based analysis for the public sector. Water consumption will grow at 0.07%, on average, per year from 2021-22, thus consumption will rise from 21.67 ml per day in 2020-21 to 22.65 ml per day in 2070-80.

3.5 Unclassified Sector water demand

Just like the public sector, the unclassified sector water consumption was forecasted using trend-based analysis. However, it is expected that water consumption will rise by 0.36% per year, on average, from 2021-22, meaning consumption will rise form 2.1 ml per day in 2020-21 to 2.59 ml per day at the end of the forecast period.

3.6 All sector water demand

Combining the forecasts for all of the above leads to a similar pattern to what is seen in services sector, which is unsurprising considering it is the sector with the largest water consumption. After, the water consumption decline induced by the pandemic, water consumption is expected to bounce back quickly from 2021 to 2023. Hereafter the growth of water consumption becomes steadier and is expected to rise at 0.14% per year, on average, compared to the average of 4.02% from the 2 years prior.

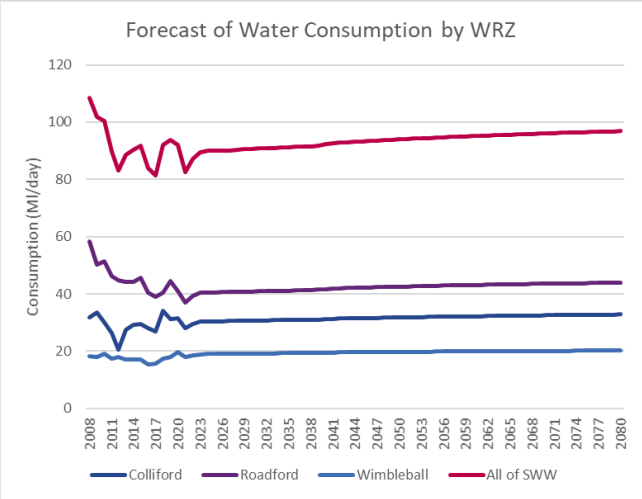
3.7 WRZ demand

Roadford has the largest water consumption levels, followed by Colliford and then Wimbleball, this pattern continues when the consumption patterns are forecasted out to 2080. The patterns of the forecasts are very similar to the SWW area as a whole as each water resource zone see a

strong recovery from the pandemic between 2021-2022 and 2023-2024, before growth levels off. This can be seen in figure 3.7

Specifically, water consumption growth averages 2.93% in Colliford, 3.28% in Roadford and 2.05% in Wimbleball, from 2021 to 2024. However, after that growth slows and continues at a steady rate to the end of the forecast horizon at 0.13%, 0.14% and 2.05%, respectively.

Figure 3.6: Water consumption split by WRZ



3.8 Bournemouth Water

After a fall in the water consumption levels due to the pandemic, consumption is expected to bounce back with strong growth in 2021 at 9.23% and 2.87% in 2022. Following this, consumption growth will begin to fall before averaging 0.09% a year, between 2026-27 and the end of the forecast horizon. Therefore, water consumption will stay just below 20ML/ day for Bournemouth Water.

4. Appendix A

4.1 Mapping of industry codes to aggregate sectors

The following table details the mapping of Experian's 12 broad sectors to the aggregated industry sectors used for the forecasts.

Experian Broad Sector Code	Experian Broad Sector Name	Aggregate Sector
AFF	Agriculture, Forestry & Fishing	Agriculture
CON	Construction	Non-Services
EXT	Extraction & Mining	Non-Services
MAN	Manufacturing	Non-Services
TRS	Transport & Storage	Non-Services
PUB	Public Services	Public
AFR	Accommodation, Food Services & Recreation	Services
DIS	Wholesale & Retail	Services
FIN	Finance & Insurance	Services
ICO	Information & Communication	Services
PRI	Professional & Other Private Services	Services
UTL	Utilities	Services

The following table details the mapping of South West Water's detailed sector labels to the aggregated industry sectors used for the forecasts.

South West Water Sector Description	Broad Sector
Agriculture and Horticulture	Agriculture
Advert Stations & Rights	Services
British Telecom	Services
Cemeteries/Crematoria etc	Services
Cinemas	Services
Production	Non-Services
commercial owner/domestic property	Services
Crown Dwelling House	Public
Crown Occupation	Public
Docks, Harbours & Canals	Non-Services
Electricity	Non-Services
Factories, mills etc	Non-Services
Garage, P/Station, C/parks	Non-Services
Gas	Non-Services
HH Agricultureicultural Dwelling	Agriculture
Holiday Camps/C'van Fields	Services
Hotels and Boarding Houses	Services
L/Auth School/College	Public
Library/Museum/Gallery	Services
Lock-up Garages	Non-Services
Markets	Services
Mineral Producing Hered'	Non-Services
NH Agricultureicultural Dwelling	Agriculture

NH Building Supply	Agriculture
Non L/Auth School/College	Public
Non NHS Hosps/Clinics etc	Public
Not Otherwise Classified	Unclassified
Offices & Banks in Offices	Services
Other Entertainment Plcs	Services
Other Transport	Non-Services
Outside area (i.e WESSEX)	Unclassified
Post Office	Non-Services
Publiclic Houses	Public
Publiclic Wash Houses/Baths	Public
Radio, Television etc	Services
Residential clubs	Services
Restaurants	Services
Sewage/Refuse Disposal	Services
Shops & Private Accom	Services
Shops, Banks, Cafes	Services
Single Caravan Sites	Services
Social & Comm Ctrs/Halls	Services
Sports Grnds/Golf/Racing	Services
Theatres and music halls	Services
Town Hall/Municipal Office	Public
Troughs	Agriculture
Uni & Uni Colleges	Public
W/houses, Stores & W/shops	Services
Water	Non-Services