Research-inspired Policy and Practice Learning in Ethiopia and the Nile Region

Towards a regional assessment of self supply potential in SNNPR, Ethiopia

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Research-inspired Policy and Practice Learning in Ethiopia and the Nile Region (RiPPLE) is now a thriving independent Ethiopian NGO, with a reputation for high quality independent research, capacity building and knowledge management. RiPPLE started life as a 5-year Research Programme Consortium funded by UKaid from the Department for International Development aiming to advance evidence-based learning on water supply and sanitation (WSS). The RiPPLE Consortium was previously led by the Overseas Development Institute (ODI), working with the College of Development Studies at Addis Ababa University; the Ethiopian Catholic Church Social and Development Coordination Office of Harar (ECC-SDCOH), International Water & Sanitation Centre (IRC) and WaterAid-Ethiopia.

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Contents

List of Tables

List of Figures

List of Acronyms

SNNPR	Southern Nations, Nationalities and People's Region
RiPPLE	Research-inspired Policy and Practice Learning in Ethiopia and the Nile
DRMFSS	Disaster Risk Management and Food security Sector (formerly DPPA, Disaster Prevention and Preparedness Agency, Ethiopia)
SRTM	NASA Satellite Radar Topography Mission
USGS	United States Geological Survey
FEWS NET	Famine Early Warning System Network

Executive summary

A mapping approach was used to assess the potential for self supply within Southern Nations, Nationalities and People's Region (SNNPR), Ethiopia. Self supply can be defined as improvement to water supplies developed largely or wholly through user investment, usually at household level. The study was funded by the RiPPLE Programme (Research-inspired Policy and Practice Learning in Ethiopia and the Nile Region) as part of a wider research project to understand the potential contribution of self supply in achieving the Ethiopian goal of universal access to rural water in SNNPR.

The mapping approach was based on three main components: the need for household water supplies; the opportunity for households to develop their own water supply; and the means of households to develop their own water supply. Need was mapped using water supply coverage data from 2009 collected by the Bureau for Water Resources with areas of higher need identified as those where coverage was relatively low. Shallow groundwater potential was used as an indicator of opportunity; this was mapped using land surface form (a United States Geological Survey dataset) and long term rainfall, with higher potential being those areas classified as "smooth" or "irregular plain" and having long term rainfall greater than 500 mm. Income data from livelihood surveys undertaken for the Disaster Risk Management and Food Security Sector (DRMFSS; formerly the Disaster Prevention and Preparedness Agency) in 2005 were used to map those households with higher income, which was assumed to correlate with greater means to develop their own water supplies. The three components were combined to give an overall assessment of the potential for self supply.

The output is a preliminary assessment. The exercise proved useful in exploring dataset availability and in producing an output that can be used in further studies. With additional resources and time it would be possible to include the necessary local expert input for ground-truthing and to refine the methodology.

1 Introduction

This study uses a mapping approach to assess whether readily available spatial datasets and expert knowledge can be used to assess regional potential for self supply in Southern Nations, Nationalities and People's Region (SNNPR), Ethiopia. Self supply can be defined as improvement to water supplies developed largely or wholly through user investment, usually at household level. The study was funded by the RiPPLE Programme (Research-inspired Policy and Practice Learning in Ethiopia and the Nile Region) as part of a wider research project to understand the potential contribution of self supply in achieving Ethiopia's goal of universal access to rural water in SNNPR (Sutton *et al.,* 2011). An added value of a mapping approach is that it facilitates dialogue between stakeholders, as well as capturing expert input and the available data (MacDonald *et al.,* 2009).

The specific objectives of the study were to:

- identify if suitable datasets exist that could be used to map self supply potential
- examine whether, with expert input, validated maps of self supply potential could be produced.

Resource and time constraints and difficulties in sourcing and deriving suitable digital datasets meant that these objectives were not fully addressed. However, the exercise proved useful in exploring dataset availability and in producing preliminary outputs that could be used in further studies.

2 Planned approach

The planned approach was based on three components that help assess the potential for self supply. Spatial datasets were obtained to map each of these components:

The need for household water supplies

This is a prerequisite for self supply intervention. Water supply coverage statistics collected by the Bureau of Water Resources were used as the indicator for the need for household supplies. Need was deemed higher where the water supply coverage was lower.

The opportunity for households to develop their own water supply

Water resources suitable for on-site household water supply include groundwater wells, rainfall collection and springs. The approach focuses only on the development of wells, as rainfall harvesting opportunities are ubiquitous and seasonal spring development limited.

The means of households to develop their own water supply

An assumption of the approach was that households with a higher income would be more likely to develop their own water supplies. The livelihood surveys undertaken for the Disaster Risk Management and Food Security Sector (DRMFSS; formerly the Disaster Prevention and Preparedness Agency) in 2005 were identified as a good source of data on income.

Mapping the three components requires: suitable datasets to be identified; digitisation of the datasets; and in some cases the combination of digital datasets. This proved a time-consuming exercise. Once datasets for each of the components were produced, initial thresholds were set and the components combined to produce an overall preliminary assessment of potential. The planned approach involved a cycle of local expert knowledge input to review the thresholds and test the combined outputs but this was not possible given time and resource constraints. The opportunity for further scrutiny of the outputs from the study is considered in Section 4 of this report.

3 Developing the preliminary assessment

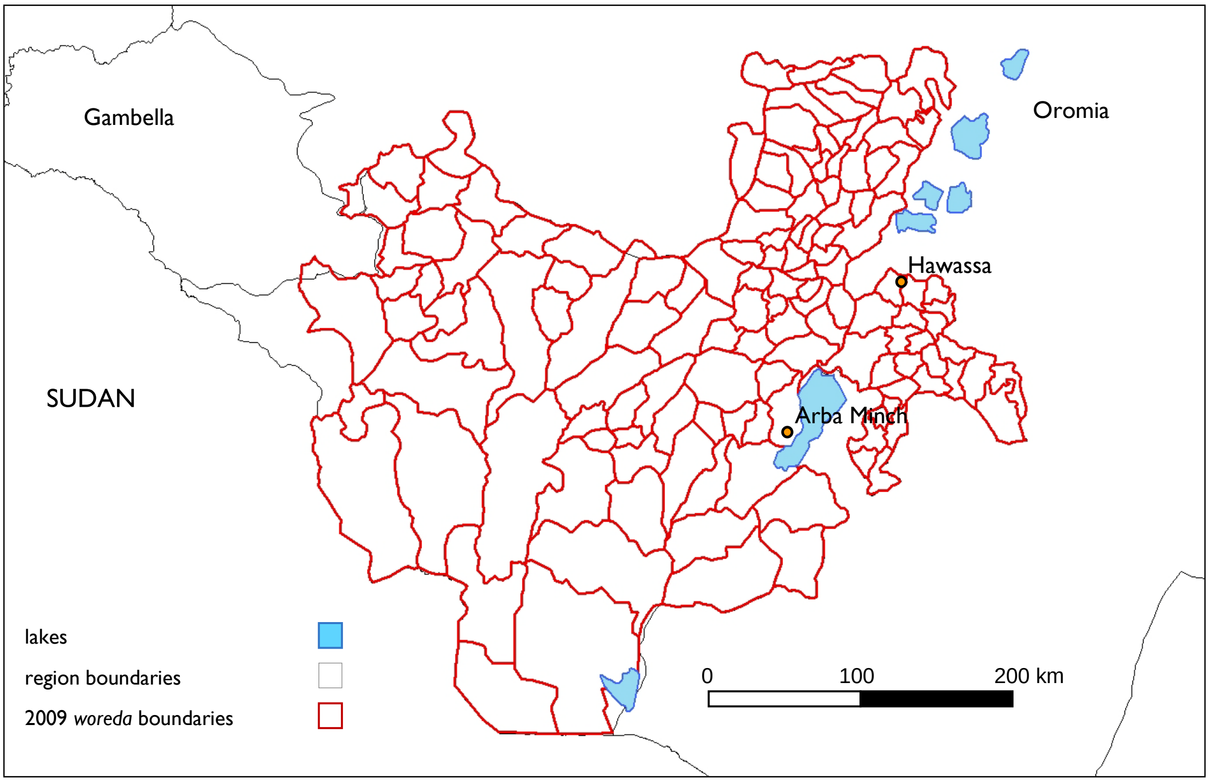
The development of each component of the self supply potential assessment is described below. Challenges in mapping the components are discussed. The results from combining these components into an overall self supply potential map are then presented.

3.1 The need for household water supplies

Although availability of communal sources of drinking water will not stop households from developing their own, the hypothesis underlying this study was that the demand for household supplies would be greater where alternative communal supplies are not available. Government water supply statistics were identified as a ready means to identify those areas where coverage is relatively poor and therefore demand for self supply likely to be higher. Water supply coverage data for SNNPR collected by the Bureau of Water Resources in 2009 were used. This dataset provides information by *woreda* (district).

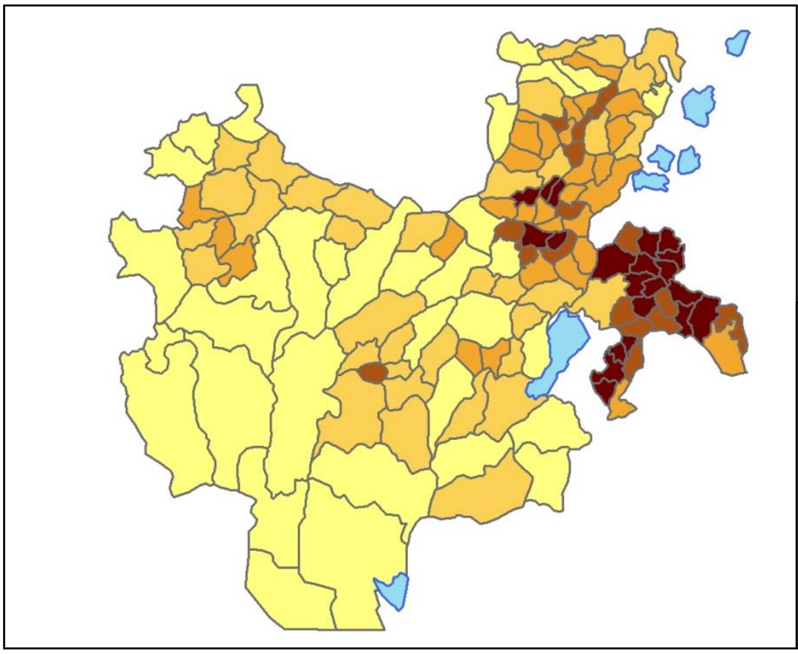
A problem arose finding a shapefile with *woredas* that corresponded with those in the 2009 dataset. After some time approaching organisations that hold spatial datasets and searching the internet, a pdf version of a map was found that matched the *woredas* listed within the 2009 water supply coverage dataset. These boundaries were then digitised (Figure 3.1).

Figure 3.1 2009 *woreda* boundaries for SNNPR



The 2009 water coverage dataset provides information on the total number of functioning and non-functioning water supply points in rural and urban areas. The water supply points are categorised by type. These include: hand dug wells with hand pumps; shallow wells with hand pumps; deep wells with distribution; springs with distribution; spot springs and river intake with distribution. The dataset also provides information on the number of people deemed to have access to an adequate source of water, based on the Government's criteria. The assumption made in mapping the potential for self supply is that the number of people who are deemed not to be covered can be used as an indication of the demand for water. It is in rural areas that the self supply approach has greater application. The data on rural population in each *woreda* not served was normalised for *woreda* area and mapped as population per square kilometre (Figure 3.2). This dataset is used as the indicator of demand for household water supplies. When combining this dataset with other components in the preliminary self supply potential map (see section 3.4), the dataset was simplified by using the threshold of 150 persons not serviced per square kilometre, to differentiate between lower and higher demand. This threshold was chosen to have a similar number of *woredas* in the lower and higher demand categories.

Figure 3.2 Density of population not serviced by communal water supplies in SNNPR in 2009



3.2 The opportunity for households to develop their own water supply

This component of the self supply assessment addresses the potential to develop a household groundwater supply. There are many physical factors which determine whether a shallow hand dug well is feasible and appropriate at a location:

- Rock at shallow depths is sufficiently permeable and has enough storage to allow an adequate rate of water abstraction.
- The well can yield an adequate supply of water throughout the dry season and during periods of drought. This is a factor both of natural groundwater level fluctuation and the drawdown of water level in the well due to pumping/lifting.
- It is possible to dig the rock while it is also consolidated enough not to collapse during well construction.

- The quality of groundwater is such that health effects are not significant in comparison with the benefit of improved access to a sufficient quantity of water.

Developing a spatial dataset which addresses all of these elements is challenging. In terms of the permeability and storage of rock, although maps of groundwater potential exist for Ethiopia, these relate primarily to the potential to abstract water using boreholes drilled to a depth greater than is accessible by shallow hand dug wells. In SNNPR the primary rock types are:

- Precambrian basement rocks
- Tertiary and Quaternary volcanic rocks
- Quaternary unconsolidated sedimentary rocks.

The potential for shallow groundwater supplies from the basement and volcanic rocks is dependent on there being a sufficiently deep weathered zone that creates permeability and storage in the rock and also enables wells to be constructed. Weathering in these rock types is highly localised, being dependent on factors such as bedrock mineralogy and texture and the degree of fracturing. The degree of weathering or the productivity at shallow depths is not mapped on a regional scale.

The initial approach taken to assess the shallow groundwater potential involved developing a map of depth to groundwater for SNNPR. A method has been applied elsewhere by the British Geological Survey (McKenzie *et al.*, 2010) which assumes that river levels are an expression of the water table and uses the heights of rivers as observations between which a linear interpolation of groundwater levels can be made. River levels are obtained by combining perennial river course with topography. Datasets of perennial rivers are available for SNNPR and detailed topography was obtained on a 90 m grid from the NASA Satellite Radar Topography Mission (SRTM).[1] These are shown in Figure 3.3. However, the high relief in SNNPR and the paucity of perennial water courses meant this approach was not appropriate and it was not possible to use the output for the assessment of self supply; significant areas had groundwater levels that were mapped as above ground level (Figure 3.4), in some areas hundreds of metres above ground level.

Ayenew *et al.* (2008) identified that the majority of rural communities depend on shallow hand-dug wells from alluvial deposits in plains and in strips along river courses. The second approach taken to map the shallow groundwater potential for SNNPR was to identify these areas based solely on topography. A dataset was used, produced by the United States Geological Survey (USGS) which categorises Africa by 'land surface form'. [2] Land surface form again uses SRTM topographic data and is a function of slope and local relief. The dataset categorises the land surface by seven types: smooth plains, irregular plains, escarpments, hills, breaks/foothills, low mountains and high mountains/deep canyons. The dataset covering SNNPR is shown in Figure 3.5. It is hypothesised, based on what are currently reported to be the main locations for shallow hand-dug wells, that those areas identified as smooth or irregular plains are likely to have the highest potential. Some validation of this approach was obtained by the moderate correlation between the proportion of higher shallow groundwater potential in each *woreda* against the number of functioning hand-dug wells in that *woreda* (Figure 3.6; correlation coefficient of 0.42 assuming a linear relationship).

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[1] http://www2.jpl.nasa.gov/srtm/

[2] http://rmgsc.cr.usgs.gov/ecosystems/usa.shtml

Figure 3.3 Topography and perennial rivers in SNNPR

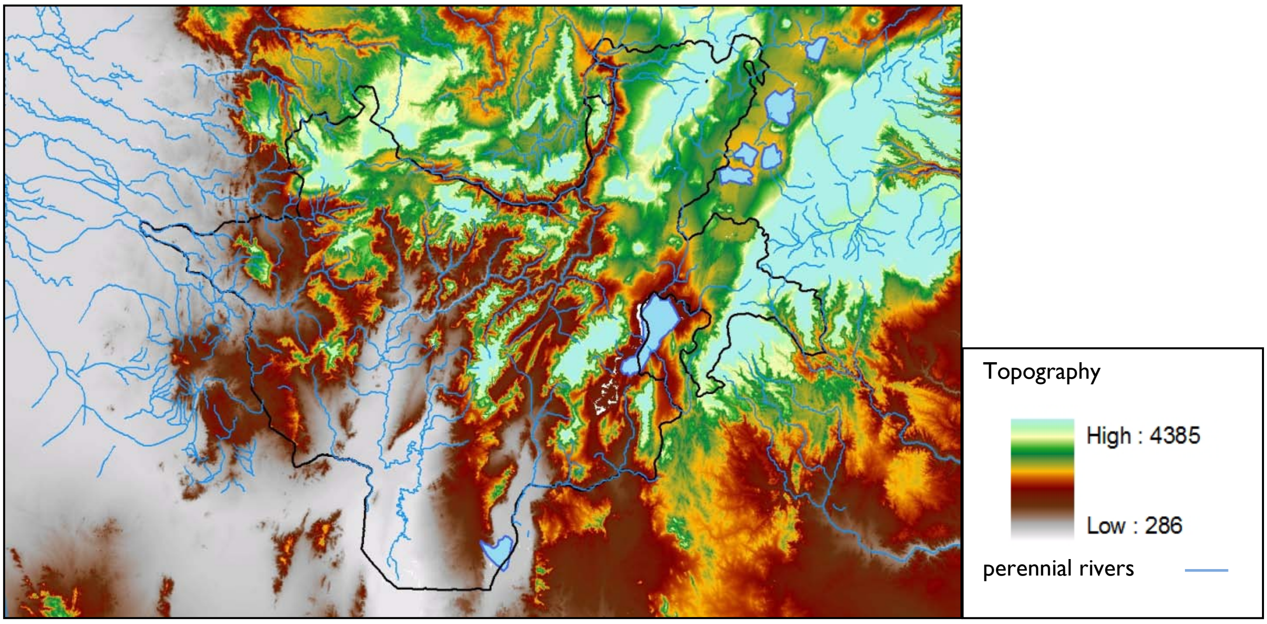


Figure 3.4 Output from depth to groundwater calculation for SNNPR

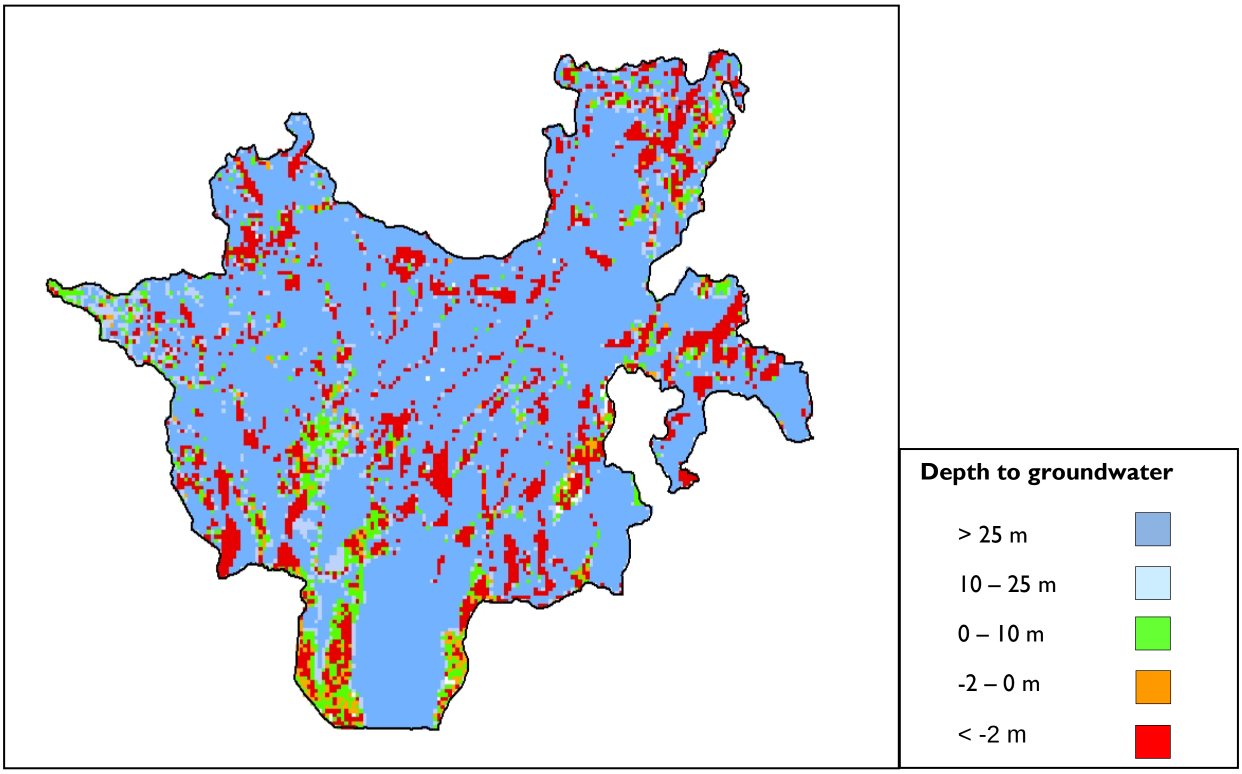


Figure 3.5 Land surface form as defined by the USGS

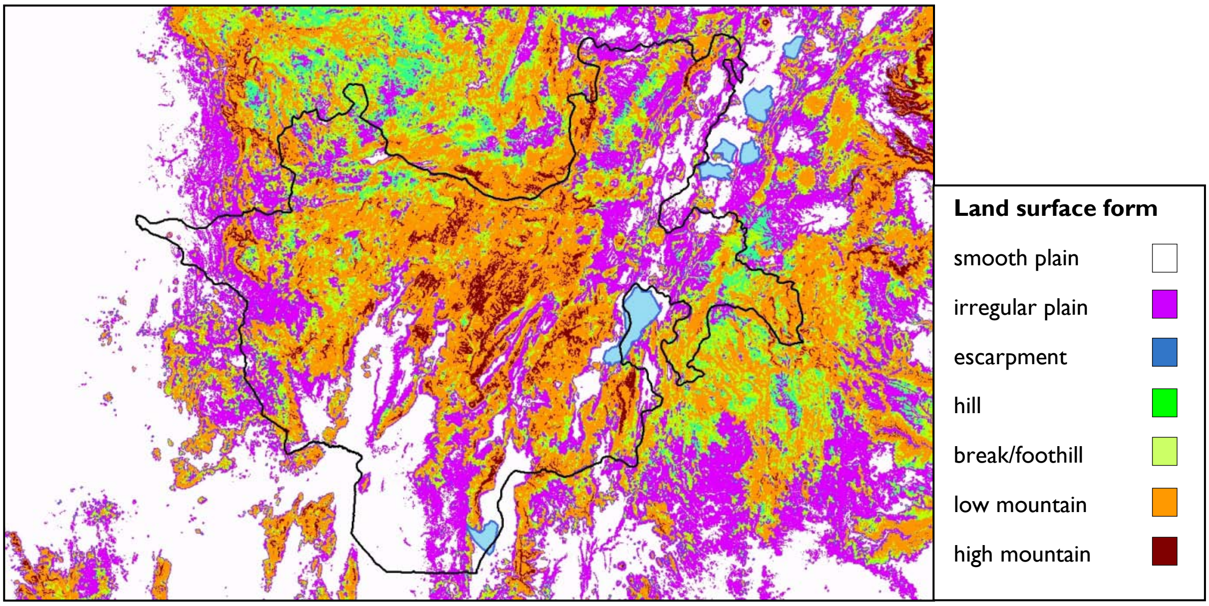
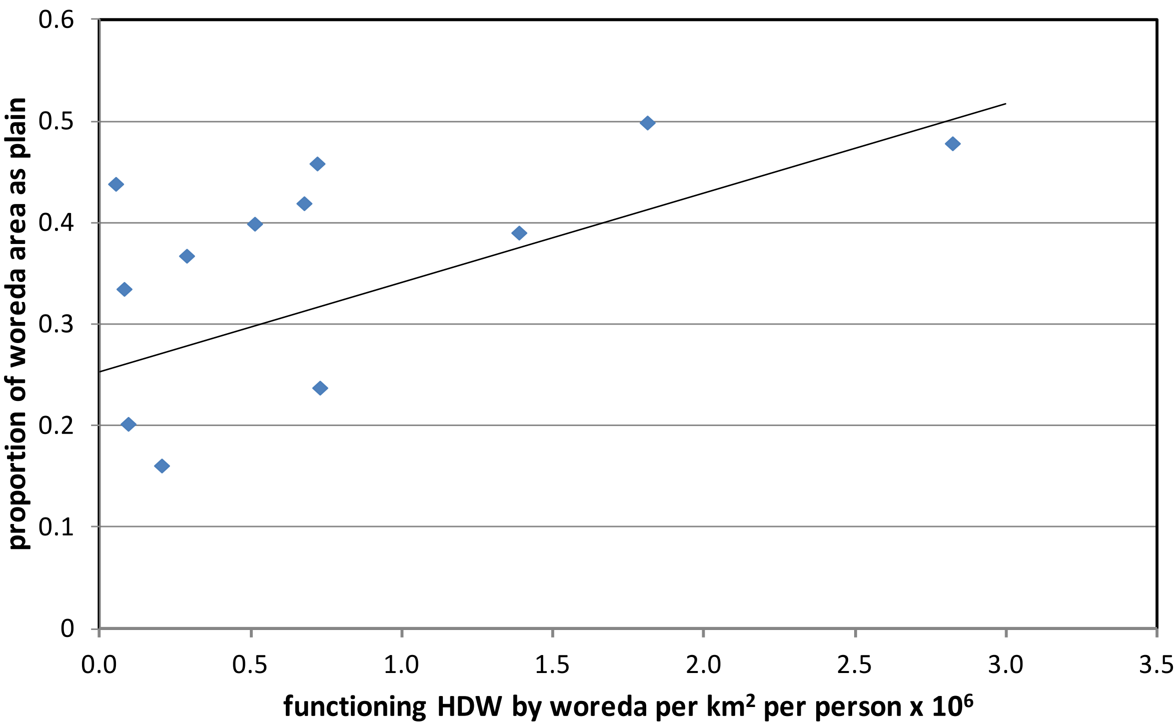
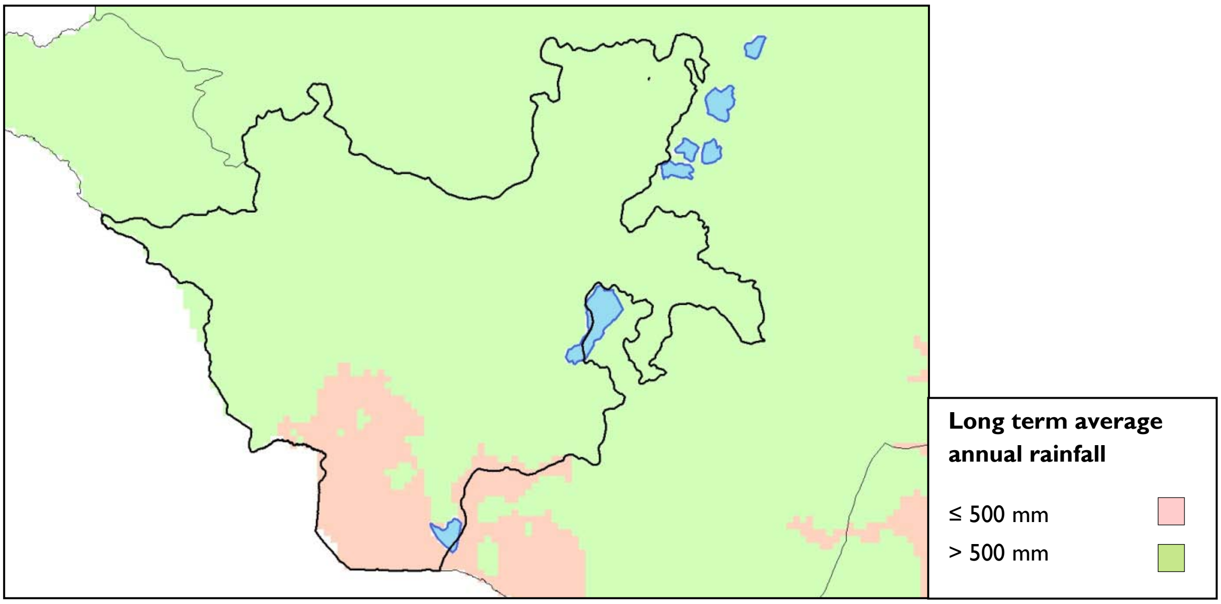


Figure 3.6 Correlation between the proportion of *woreda* categorised as 'plain' within the land surface form dataset and the density per population of functioning hand-dug wells identified in the 2009 water coverage dataset. (Note: only *woredas* with greater than 10 functioning hand dug wells were used.)



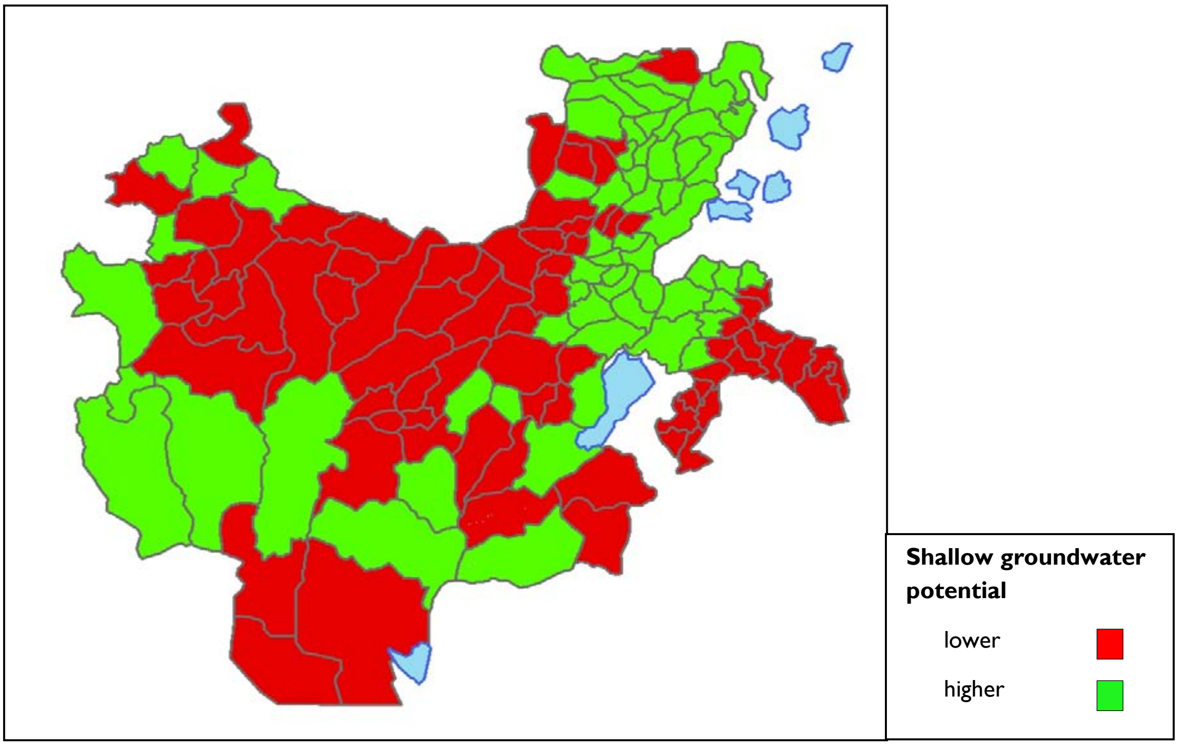
As well as having a suitable hydrogeological setting, self supply potential requires adequate groundwater recharge. A simplified approach was taken to assessing where groundwater recharge is significant, using long term rainfall data for Africa for 1951 to 1995. These data were used to produce maps of the distribution of long term average annual rainfall and those areas with less than 500 mm per annum on average were differentiated (Figure 3.7) and assumed to have limited groundwater recharge. The rainfall data could have been used to look at drought vulnerability which would help quantify sustainability of water supplies but it was thought including this as another layer would overly complicate the approach.

Figure 3.7 Long-term average annual rainfall in Ethiopia based on 1951 to 1995 data



The land surface form map was combined with the rainfall map, with those higher potential areas coincident with areas with long term rainfall less than 500 mm being redefined as having lower potential. The output is an attempt to map the shallow groundwater potential. As demand for self supply uses *woreda*-level data, the shallow groundwater combined dataset was aggregated using the 2009 *woredas*. The *woredas* were classified as higher groundwater potential where greater than one third of its area is underlain by suitable land surface form and long term average annual rainfall is greater than 500 mm/year (Figure 3.8).

Figure 3.8 Shallow groundwater potential by 2009 *woreda* for SNNPR



3.3 The means for households to develop their own water supply

The hypothesis has been made that household groundwater supply development is more likely to occur among higher income families. It is acknowledged that the results of the case studies within the RiPPLE Self Supply project indicate that income does not correlate well with self supply potential (Sutton *et al.*, 2011). Education levels within households correlated better with household well ownership and further work on the approach could focus on this as a determining factor. However, the initial proposal to use household income as an indicator was followed, as the case study insights have not yet been tested for their general applicability.

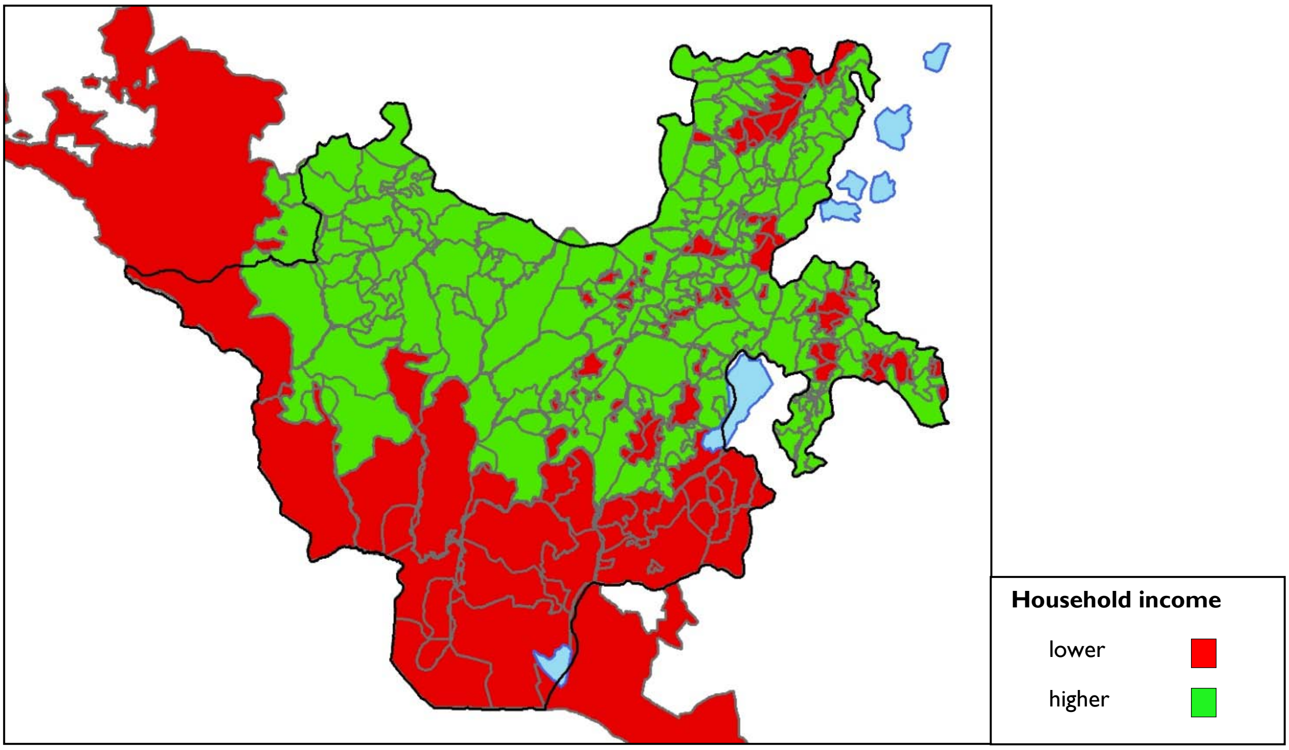
The only regional source of data on household income that could be obtained came from livelihood surveys undertaken in SNNPR by FEWS NET (Famine Early Warning System Network)[3] for the DRMFSS. Data resulting from the surveys include total household income for wealth groups within each livelihood zone as well as the average household income for the zone. The income comes from crops, livestock, labour, aid, self-employment and other non-defined sources. The total income is expressed in percentage of kilocalories (kcals) intake relative to that equated with the absolute poverty line (2200 kcals; Bigsten *et al.*, 2008).

To simplify the dataset for the self supply assessment a threshold of the food poverty line was chosen to categorise income. The intake associated with the food poverty line is in the order of a factor of two greater than that of the absolute poverty line. Above this threshold there is a greater probability that there may be sufficient financial security for a family to invest in a household water supply point.

[3] www.fews.net

The number of households above the food poverty line per km^2 was calculated for each livelihood zone using average household sizes (provided by the livelihood survey) and livelihood zone populations and areas. A further threshold was then set of an average of one household per km^2 above the food poverty line and the livelihood zones classified on whether they were above or below this threshold. Those above it are considered to have higher potential for self supply and those below it, lower potential (Figure 3.9).

Figure 3.9 Household income by livelihood zone: zones above or below the threshold of 1 household per km^2 above the food poverty line. (Note: this includes all livelihood zones with some area within SNNPR.)



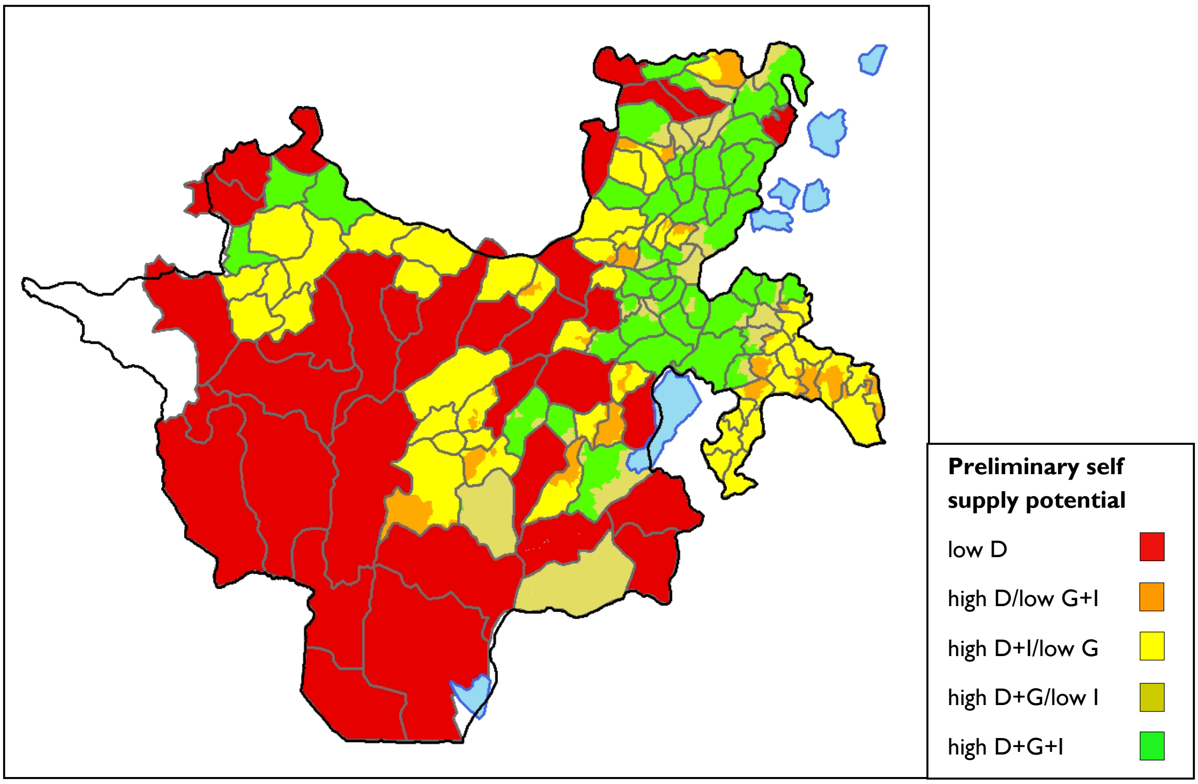
3.4 Combining the component datasets

The individual datasets were combined to produce an overall preliminary assessment of self supply potential (Figure 3.10). The combined classifications are as follows:

- Lower demand
- Higher demand + lower shallow groundwater potential + lower income
- Higher demand + lower shallow groundwater potential + higher income
- Higher demand + higher shallow groundwater potential + lower income
- Higher demand + higher shallow groundwater potential + higher income

Where demand is low then the status of the other components is not taken into account.

Figure 3.10 Overall preliminary self supply assessment based on demand (D), shallow groundwater potential (G) and income (I)



The overall self supply potential classification of the 2009 *woredas* is provided in tabular form in Table 1. Where a *woreda* includes more than one classification, the one which covers the greatest proportion of the area is used. The table indicates those *woredas* (in bold) that have been assessed by UNICEF as having high self supply potential, based on expert knowledge. There is a very poor correlation between the UNICEF assessment and that resulting from the preliminary assessment presented here. The reasons behind the discrepancy have not been examined.

Table 3.1 Preliminary assessment of self supply potential by woreda. (Note: those identified by UNICEF as having high potential are in bold.)

Region/Zone	***Woreda*/Zone**				
	low demand	**high demand low potential low income**	**high demand low potential high income**	**high demand high potential low income**	**high demand high potential high income**
Alaba					Alaba
Amaro	Amaro				
Basketo			Basketo		
Bench Maji	**Bero** **Guraferda** Maji **Mienit Goldia** Mienit Shasha **Surma**		**Debub Bench** **North Bench** **Sheko** **Shewa Bench**		
Burji	Burji				
Dawuro	**Gena Bosa** Isara Loma		**Mareka** Tocha		
Debub Omo	Benatsemay Dasenech Gnagatom Hammer Selamago		Debub Ari Semen Ari	Mallie	
Derashe	Derashe				
Gamugofa	Demba Gofa Kemba Kucha Mirab Abaya	Chencha	Bonkie **Boreda** Dita Geze Gofa Mellokoza Oyda Uba debre Tsehaye		Arba minch Zuriya Daramalo Zala
Gedeo			Bule Dilla Zuria Gedeb Kochere Wenago Yirgachefe		
Gurage	Abeshage Cheha Ezha Mareko	Endegagne Gedebano Gutazer		Geta Gumer Mihur Aklil	Enemor & Ener Kebena Meskan Sodo
Hadiya			Duna Gibe Misha Soro	Misrak Badawacho	Analemo Gombora Lemo Mirab Badawacho Shashogo
Keffa	Cheta **Decha** Saylem		Bitta Chena Gimbo **Menjwo** **Tello**		**Gesha** Gewata
Kembata Tembaro		Haderona Tunto Zuri	Angacha Demboya Doyogena Tembaro		Kachabira Kedida Gamela
Konso				Konso	
Konta	Konta				
Sheka	Andracha **Masha**				Yeki

Region/Zone	***Woreda*/Zone**				
	low demand	**high demand low potential low income**	**high demand low potential high income**	**high demand high potential low income**	**high demand high potential high income**
Sidama		Aleta Wendo Bona Zuria Dara	Arbegona Aroresa Bensa Bursa Chire Gorchie Hula Malga Wensho	Dale Shebedino	Aleta Chuko Awassa City Awassa Zuria Boricha Loka Abaya Wondogenet
Silitie				Alicho Wurio	Dalocha Lanfuro Mirab Azernetbere Misrak Azernetberber Sankura Silti Wulbareg
Welayta	Kindo Koyisha		Boloso bombe Kindo diaye		Bolososore Damot Gale Damot Pullasa Damot Sore Damot Weyde Dugna fango Humbo Offa Sodo Zuria
Yem	Yem				
TOTAL	**33**	**7**	**46**	**9**	**40**

4 Comments on the methodology, results and way forward

The methodology described in this report assumes the three primary components of an assessment of self supply potential are need, opportunity and means. It is recognised that the use of these three components in the methodology would benefit from critical review. Comments are provided below on recognised issues and weaknesses associated with the approach taken.

Need

It is felt that the use of water coverage data is a robust approach to assessing need.

A relatively arbitrary threshold was used which provided a balance of higher and lower demand across SNNPR. This threshold needs to be reassessed on the basis of water coverage targets.

Opportunity

The limitations of a simplified approach to assessing shallow groundwater potential are felt to be more significant than with other components. The simplified approach was dictated both by the lack of data but also the aim to avoid complexities that would make assessments at regional scale difficult to interpret.

Shallow groundwater potential exists across all the geological formations in SNNPR and the volumes of water required to service a household with a potable supply are very small. The groundwater potential assessment identifies relative and not absolute potential and is careful to use the terms 'lower' and 'higher' and not low and high.

The input of expert knowledge and local experience is crucial for this component, both to provide a critical review of the methodology used and to validate the outputs. This had not been possible at the time of reporting.

Other sources of household water supply such as rainwater harvesting and development of small springs have been ignored in this assessment and it may be deemed necessary to incorporate these in a complete analysis.

Means

Questions remain as to whether income determines self supply potential. As has already been stated, the results from the case study woredas indicated that where households owned wells this was not correlated with income and that education was a stronger factor. More work to map this component is necessary. It does seem that if this aspect is to be pursued the livelihood surveys provide a useful dataset from which more insights could be obtained.

The hierarchy of thresholds used to map this component, as described in Section 3.3, is also not ideal. Were this component to be refined, based on the current approach, close scrutiny of these thresholds would be necessary.

Overall assessment

The number of classes of self supply potential resulting from the combination of component datasets seems reasonable considering the objective of the study, which is to identify *woredas* that provide the best conditions for pilot studies. However, it may be considered by some that this approach to the classification of the component layers is oversimplified.

The methodology currently involves arbitrary thresholds and if it is to be taken forward a sensitivity analysis would be essential, as would the use of any available validation data, for example the case studies areas used for the main RiPPLE self supply project.

As already mentioned, the input of experts and local experience is crucial. The approach is as much a means to facilitate discussion and develop consensus as it is to produce a tangible product that maps potential. So far there has been very little engagement with experts and stakeholders due to the lack of time available for the study and the availability of the experts approached.

Having developed this methodology, application in another area to produce a preliminary map, prior to the stage of consultation with local experts, is estimated to take 3 days assuming no major issues with the datasets.

5 References

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