EXPLORING THE EVIDENCE OF WATER-ENERGY-FOOD NEXUS LINKAGES TO SUSTAINABLE LOCAL LIVELIHOODS AND WELLBEING IN SOUTH AFRICA

Report to the
Water Research Commission

edited by

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Executive Summary

Following the global trend, the water-energy-food (WEF) nexus has been identified as an important perspective in South Africa for achieving sustainable and integrative natural resource management. Responding to the need for a better understanding of the interdependencies of water, energy and food at multiple scales, the Water Research Commission (WRC) has established a WEF Nexus Lighthouse. This aims to champion integrated planning and development of the three resources for South Africa.

Research into the WEF nexus at the household and community level and into the relationship between the nexus and livelihoods is minimal. Understanding these dynamics is not only a useful informant to guiding local-level strategic planning and economic development; it is especially relevant given the South African context of high unemployment, climate change, struggling water and power utilities and significant food insecurity despite national food self-sufficiency. This project set out to address the identified knowledge gap, exploring how the nexus plays out in affecting local livelihoods in South Africa, and how this understanding can support more equitable sustainable development outcomes at the household level.

The general aim of this study was to provide foundational and ground-tested evidence that can inform community development and empowerment as well as the WRC Lighthouse theme on WEF Security, and to identify knowledge gaps so as to inform the direction of future WEF nexus research to support equitable sustainable development in South Africa. The following specific objectives were addressed. First, to conduct a systematic knowledge review of the evidence on the WEF nexus at different scales, with a focus on how the nexus affects livelihoods at household and community level. Second, to use case studies in catchment areas that span rural and urban communities to explore how the WEF nexus plays out 'on the ground' and mediates the livelihoods of different actors at the local scale; specifically, with reference to how they are embedded within river catchments and their associated governance systems for water, energy and food. Third, to strengthen awareness of nexus thinking for integrated development planning and natural resource management at different scales amongst decision-makers, and extract recommendations for policy as well as research in order to move into an era of informed decision-making. Fourth, to identify key knowledge gaps in the interplay between WEF nexus and development that will need to be answered by longer-term research projects. Fifth, to trial a process of involving and up-skilling local youth together with their communities, thus empowering them to better understand how the nexus impacts on their financial outcomes and economic opportunities.

The WEF nexus is argued to be valuable for understanding complex systems, and for decision-making to achieve macro-scale sustainable development. However, the ultimate evaluation of success for achieving sustainable development should be at a different scale, namely, improved and sustainable livelihoods of individuals and households especially in vulnerable communities. Globally, nexus research has so far remained weak in identifying how the nexus is interlinked with livelihoods. In the knowledge review, we probed the existing literature for evidence of the conceptual and practical utility (or not) of a combined WEF nexus and

sustainable livelihoods approach (SLA). After assessing the compatibility of the two approaches, we interrogated four key empirical papers that demonstrate how the WEF nexus at different scales intersects with livelihoods. We found that a simple combined approach may not lead to greater insights into the linkages between the nexus and livelihoods. In their current application, both approaches fail to account in meaningful ways for the political economy and power constellations within and across decision-making levels. The relationship that local communities have to their local natural resource base in times of rapid urbanization and changing livelihood trends requires further data and methods development and analysis. Nevertheless, opportunities exist in the combination of both approaches to gain a deeper understanding of the relationship, with possible implications for integrated policy and planning processes. Some of these themes were explored in the case studies and through the youth/community awareness and empowerment activities conducted in this research project.

For the case studies, a mixed method research design was employed. We explored the linkages of the WEF nexus to local livelihoods from different disciplinary angles and engaged in a transdisciplinary approach by involving the youth from communities as research assistants and knowledge co-producers. Results were interpreted within the context of governance systems for WEF at various scales. Using different types of poor households as the entry point, we examined the ways in which the WEF nexus affects livelihoods across three catchments in South Africa, namely, the Berg (Western Cape), Keiskamma (Eastern Cape) uMngeni (KwaZulu-Natal). These catchments are of major socio-economic importance and are already experiencing extraordinary development pressures and resource competition. In the WEF context, pressures include issues of water quantity and quality, land availability and use, food insecurity, energy poverty, decline in harvestable natural resources, unmet demand for water- and energy-related services, and dwindling livelihood opportunities. Two sites (communities) were identified as local case studies in the Keiskamma and uMngeni catchments, and three sites were identified in the Berg catchment. They span the rural to urban continuum, and in two catchments they provide comparisons between upper and lower/estuarine catchment areas. Four Masters students from three Universities conducted the studies for Noordhoek (within the town of Velddrif on the Berg River estuary), Pniel and Lanquedoc (upper Berg), Melani (upper Keiskamma) and Hamburg (Keiskamma River mouth), and Sobantu (mid-uMngeni) and Mpophomeni (upper uMngeni).

The research questions and design of each study were adapted according to specific research interests (Table 1), and the research methods were comprised of a sub-set of the following instruments. Cross-site comparative analyses were conducted where the same method was used.

- A set of indicators from the South African National Census 2011 – 7 sites (household)
- A household questionnaire which captured quantitative and qualitative data on the resident's livelihoods and household WEF security – 6 sites (household)
- Guided conversations – 2 sites (household)
- Mapping WEF resource supply systems – 4 sites (community)

- Focus group discussions – 3 sites (community)
- Photovoice – 2 sites (community)
- Semi-structured interviews with key informants at the town and municipal scales – 2 sites (town, catchment)

Data analysis was conducted using both quantitative and qualitative methods. Quantitative methods included descriptive statistics, ordinary least squares linear regression / Ordered Logit regression / correlation (Keiskamma study), and multivariate analysis (Hierarchical Clustering on Principal Components, HCPC, for intra- and inter-catchment analyses). Qualitative methods included, (i) contextualised narrative of the WEF resource supply systems at community level (narrative); (ii) contextualised narrative of specific research angle (upper Berg, uMngeni), drawing on thematic analysis.

Table A. Lenses through which the individual case studies explored how the WEF nexus materialises at the local level

Case study site	Research angle	Disciplinary focus	Scale(s)	Method
Lanquedoc and Pniel (upper Berg)	Assessment of WEF resource access and use by households with different housing structures; and the role of social relations in promoting or impeding access to WEF	Environmental Science	Household and community	Quantitative & qualitative
Noordhoek (lower Berg)	The implications of the WEF nexus on local economic development planning	Environmental Science	Household, community and municipality	Quantitative & qualitative
Mpophomeni and Sobantu (uMngeni)	Exploring the WEF nexus within communities with a non-payment culture; and scaling of resource provisioning through the hydrological lens	Hydrological Science	Household, community and catchment	Qualitative
Hamburg and Melani (Keiskamma)	Description of the WEF status at household level using a water poverty index, multidimensional energy poverty index and household food insecurity access score	Agricultural Economics	Household	Quantitative

The fifth specific research objective was addressed in parallel with the case studies. South Africa has a very high rate of youth unemployment. This study aimed to address this through trialling a process of involving a small group of local unemployed post-matric youth in data collection and community liaison support roles. This was designed to not only give them a stipend while engaged in data collection, but to upskill them through training in data collecting competencies and expose them to ‘nexus thinking’ around resource utilisation, trade-offs and synergies. It was envisaged that through this experience, the knowledge gained would become embedded within the study communities. In exchange, the youth provided a valuable segue way into the community, a font of local knowledge as well as interpretation at times. This was realised through a step-wise approach (Fig. 1) which integrated the youth involvement and community feedback with the student research process described above for the case studies. This involved the identification of partner organisations in the research sites which could act as local institutional homes for the project and to provide a local base and mentorship for the youth. Non-governmental organisations (NGOs) fulfilled this partnership role in most sites. Youths were recruited through these partnerships and trained as community research assistants. A train-the-trainers approach was used whereby the students working at the respective sites, and initially with youth leaders / community representatives, were trained in the training material which they in turn used to provide training to the respective youth cohorts in the research sites. Data collection was subsequently conducted with the community research assistants working alongside the students. This was concentrated in the household questionnaire and resource mapping. Training was also provided to other youth in the communities where possible.

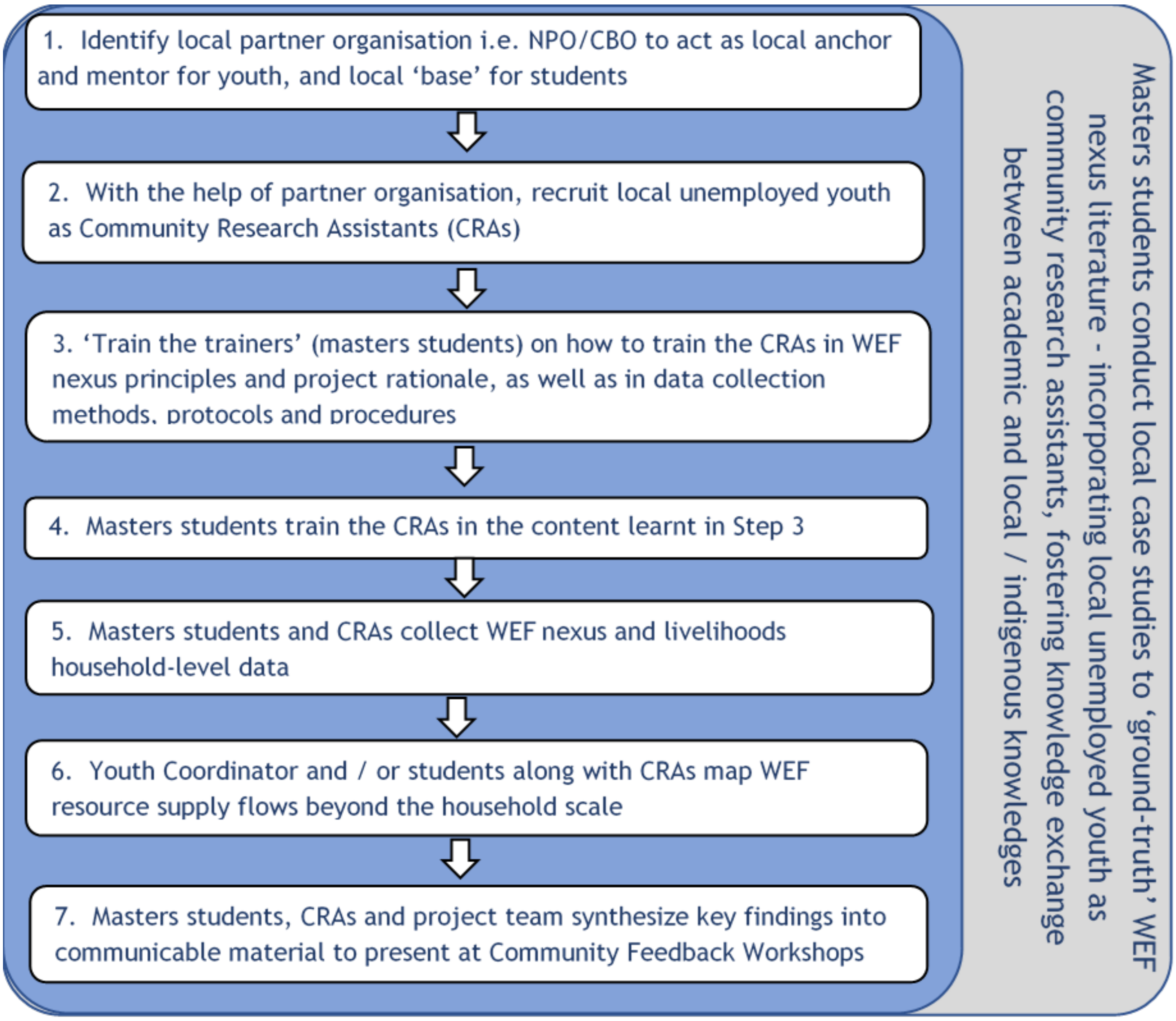

Figure A. Step-wise design framework for incorporating unemployed youth into the research project

The census data for all study sites was analysed using variables relating to household income, availability of water- and energy-related municipal services, and ownership of three household assets that require energy and/or water and have connections with food. Within the Berg catchment, Noordhoek is clearly poorer than Pniel and Lanquedoc but does have a few wealthier households, while Pniel has the highest income profile. Noordhoek and Lanquedoc have many informal dwellings. Households in the Keiskamma are poorer across the board, with Hamburg being slightly better off but also having some informal dwellings. Sobantu has fewer very poor and more wealthier households compared to Mpophomeni. Overall, households in the Berg are in the best employment and income position, those in the uMngeni are intermediate, and those in the Keiskamma are worst off.

Ownership of a refrigerator implies availability and access to electricity or gas and improves food storage thus contributing to dietary diversity and reduced food waste. Ownership of an electric or gas stove implies availability and access to modern energy sources and supports efficient and healthier cooking practices. Both electricity and piped water must be available and affordable to run a washing machine. In the Berg settlements, these variables are relatively strong overall, but in decreasing order from Pniel to Lanquedoc to Noordhoek. In the uMngeni settlements, households have access to energy and water, but very few run washing machines. The two Keiskamma settlements are comparable, with both having basic access to energy and water, but not to improved sanitation. Here, stoves are used by most households, and refrigerators by more than half, but very few households own a washing machine. Overall, households prioritise investment in stoves, followed by a refrigerator. Affordability of appliances and of energy and water to run them is a limiting factor.

The case studies yielded rich insights. Across all the sites, water, energy and food are available to households, although not always reliably and the demand is often not met. Almost all households have an electrical connection and in most of the sites they are mostly energy secure. However, use of additional sources of energy (gas, wood, candles, manure) is relatively low everywhere (and site-specific), and this could affect energy security if the electrical supply is interrupted or electricity is not affordable. Most households have access to a piped connection to a municipal supply of drinking water, either inside the dwelling or outside. Where this is not the case, such as in parts of the Keiskamma communities, alternative water sources such as rainwater are important. Here, water security is a serious issue for many households, and a major factor is the time taken to collect water. Most households are food secure or mildly food insecure, but in some communities, there are households that are moderately to severely food insecure. Almost all households purchase their food at local formal and informal outlets. Home food gardening is more prevalent in the upper Berg and uMngeni communities compared to the Noordhoek and the Keiskamma communities and depends on access to good quality land and water. Foraging and fishing to supplement household food supply is at a low level even in communities with supposed access to these natural resources.

Some finer nuances of WEF security at household level emerge from the Keiskamma catchment findings, in that household income level and thus affordability of water, energy and food are central drivers. Households that can pay to meet their needs for water, energy and food enjoy WEF security. However, most households do not earn enough, and trade-offs must be made between purchases of water, energy and food. Female-headed households and those with many household members are less energy and food secure in the Keiskamma, suggesting large deficits between income and basic expenses. A reliable source of income (e.g. from agriculture) is linked to greater energy security, and farming and land ownership also lower the probability of high food insecurity in the household.

The in-depth quantitative analysis for the Keiskamma communities revealed a weak positive association between water security and household food insecurity, suggesting that as water security increases, household food insecurity increases. These findings suggest that meeting water demand through increased water purchases in communities where income levels are low may negatively affect household food security through the income substitution effect, since the two (water and food bills) compete for the insufficient household income. Attempting to address water security in such communities without addressing income deficit may fail to yield the expected water-food security improvement. The results also indicated a weak positive association between energy poverty and household food insecurity, suggesting that an increase in energy poverty can also compromise household food security. This occurs through compromised food selection choices and changes in cooking habits to accommodate low energy availability. Efforts to improve energy-food security in such low-income communities should therefore focus on providing access to additional energy sources that are not expensive, to avoid the income substitution effect.

The WEF security nexus at household level is not obvious and direct, but rather complex, depending on several socio-economic and location-specific factors. This is borne out by contrasting results for the Noordhoek community on the Berg River estuary. Trade-offs between water and electricity purchases are minimal as debt on municipal water accounts is linked to purchases of prepaid electricity units, and few households accumulate large water account debt. Food purchases, however, present opportunities for trade-offs in household budgets, with the largest proportion of households spending up to half of their income on food. Despite Noordhoek being situated in a largely rural municipality, only two respondents reported working in the agricultural sector, and only 16% reported having a household food garden. Although regarded as a fishing town, limited direct harvesting of fish resources in the estuary and bay was reported. However, 41% of respondents are employed in the fisheries sector, and a salary is the main source of income in most households. The single biggest employer in the area, the fish factory, is also the largest consumer of water and electricity in the town. The recent drought (2015-2018) resulted in the municipality not being able to sustain the required level of water supply to the factory, and the factory was forced to invest in a desalination plant, an energy-intensive technology. The fish factory – the very industry the town was developed around – therefore provides an iconic example of the intersection of the WEF nexus and livelihoods at the town scale. Overall, the study highlighted that adequate municipal service delivery has a positive influence on household WEF security. However, there was limited evidence of a nexus intersection with livelihoods at household level. As soon as the spatial scale was extended beyond the household to the town level, the nexus became visible and a connection with livelihoods emerged, as illustrated by the fish factory.

The qualitative study conducted in the uMngeni catchment was confronted by a particular challenge in this region, namely, the culture of non-payment for municipal services received by households. Most of the households are government grant or pension holders with a significant portion of households living under the poverty line and unable to pay for water and electricity. Another reason for non-payment is that people choose not to pay for basic services because they feel these services are supposed to be provided to them for free. Further, due to corruption, the communities feel they are left in the dark about other decisions made that impact on their livelihoods and this has resulted in a breakdown of trust. Understanding the characteristics of the WEF nexus within the context of the non-payment culture became a significant focus of this case study.

In the uMngeni communities, most households are highly dependent on supermarkets for food, with approximately 70% of household monthly income spent on food. Thus, there is a strong link between income, food purchases, and payments of municipal bills (water, sewage, electricity). Inter-dependencies between the three WEF components were observed regarding spending decisions, where food always took priority over water and electricity. Illegal electricity and water connections were common. As the water and energy dimensions of the WEF nexus have 'been dealt with', in the sense that 'they have been accessed and made available', food comes first in the decision-making process, because food is essential. However, the non-payment is an issue for the service authorities who must settle the bills with the utilities they are buying from, namely, ESKOM and Umgeni Water.

The uMngeni study also investigated the implications of the WEF nexus across three scales of governance, i.e. household, community, and the broader catchment scale. The results showed that most people and organisations in the catchment are aware of the WEF nexus and its interlinkages, but implementation is lacking. Furthermore, the challenges that the catchment scale organisations have encountered in improving resources supply and sustainable development were linked to several themes: (i) updated data for setting the ecological reserve (water); (ii) learning and knowledge transformation; (iii) political interference; (iv) silo mentality and lack of collaborative governance; and (v) under-pricing of water. A collaborative approach amongst different stakeholders is essential to address these issues and develop strategies that will improve resources availability and accessibility. Here the aspect of affordability is crucial for the community members, but solutions must also acknowledge the needs of the service providers.

Three multivariate analyses were conducted across six sites in the three catchments. Overall, we found that households clustered into distinct household types based on sets of household and WEF variables. These clusters generally cut across the different communities in the Berg and uMngeni catchments, so that the geographical location (catchment or position within the catchment, and other context-specific challenges) was less important than household demographic, socio-economic and service delivery factors in explaining their WEF characteristics. However, the household-WEF typologies were very different in the Keiskamma communities, where unique demographic characteristics, economic deprivation and lack of, or unreliability of, certain basic services lead to associated WEF challenges in the households.

The clusters were separated primarily by variables describing:

- Dwelling structure and type; age and gender (Keiskamma only) of the household head; duration of residence of the household head in that community; income from a pension and/or income from wages/salary/profit; number of household members; and the number of household members contributing to income;
- Access to sources of drinking water; distance to drinking water, toilet type (flush versus other, inside versus outside), whether water demand is met; and the trend in water affordability;
- Electricity as the primary energy source; other energy sources for cooking and lighting (electricity, gas, wood, candles); and the trend in energy affordability;
- The percentage of household income spent on food; trends in food affordability and food diversity; and the growing of own food.

The first multivariate analysis included the three Berg communities and Sobantu. The focus was on household and food variables, with one water variable. One half to three-quarters of the Berg community households are young and small (four or fewer members) and are experiencing declining food security. A small group mainly from Sobantu is showing improvement in food security arising from a favourable employment situation of the head. Most of the Sobantu households and one quarter to one half of the Berg households are headed by a pensioner. In these households, size and additional income sources vary, but they are almost all experiencing declining food security.

The second multivariate analysis included the three Berg communities and the two Keiskamma communities. The focus was on household, water and energy variables. Two clusters emerged. The first cluster includes all except 16 of the 283 Keiskamma households, and three Lanquedoc households. This group of households is predominantly supported by grants and headed by older females. Water and sanitation are major challenges. While electricity is available, energy affordability has mostly declined and wood, paraffin and manure are commonly used. The second cluster of households includes all except the three Lanquedoc households, and 16 Keiskamma households. They receive income from wages/salary/profit and the household head is usually younger than 60 years, with males and females equally represented. Generally, drinking water is available in the house or yard, flush toilets are mostly used, and water demand is generally met. Energy affordability has declined in 61% of households but alternative energy sources are not dominantly used.

The third multivariate analysis included the three communities in the Berg catchment: Pniel, Lanquedoc and Noordhoek. This analysis contained the most variables representing household, water, energy and food dimensions. From the rich set of results, we highlight a few patterns. There is a clear decreasing trend in what one could term ‘settledness’ or ‘rootedness’ and maturity of a household from Pniel to Lanquedoc to Noordhoek, and this shows certain linkages to WEF security patterns. Pniel is an old community with strong roots, community cohesion, and established infrastructure. This shows in the mostly brick houses with private (indoor) water and sanitation. Although pensioner-headed households make up half the community, younger and smaller households also enjoy these facilities. However, all households are becoming increasingly less WEF secure owing to affordability challenges, especially in Pniel. Energy and food purchase substitutions take the form of using gas rather than electricity for cooking, and growing food, respectively.

Lanquedoc is in transition: one third of households are ‘rooted’, and another one third are growing their ‘roots’. Both types live in brick houses with indoor water and sanitation. The final third of households are young, small (4 or fewer members) and mostly living as ‘backyarders’ in zinc metal sheet dwellings. They typically access water and toilets (communal flush or bucket) outside their dwelling, making water and sanitation their biggest challenge, together with financial constraints. Energy substitution occurs in some households through the use of gas and wood for cooking and other purposes. Two households in Lanquedoc are unique in that they both have no access to electricity and use only wood for cooking and candles for lighting. Lanquedoc thus shows high variability in household-WEF situations. Overall, most households are experiencing declining WEF affordability, possibly linked to rental and service provision costs to landlords.

Noordhoek shows less variability in household-WEF situations than Lanquedoc. Although part of the settlement is well-established, many households are in the stage of growing their 'roots', with younger heads and fewer members. These households live in brick houses with indoor water and sanitation and use electricity almost exclusively as their energy source. However, a sizable number of households are backyard dwellers in zinc metal sheet structures as described for Lanquedoc. The main WEF challenge in Noordhoek relates to water and sanitation, mainly in the informal dwellings. Overall, WEF affordability is declining, as there are more limited job opportunities here compared to the other two Berg settlements.

In summary, three general WEF situations emerge from the intra-Berg multivariate analysis:

1. Private water and sanitation facilities are available, WE demand is met, and WE affordability is stable or improving (very small number in all communities).
2. Private water and sanitation facilities are available, WE demand is met, but WE resources are becoming less affordable.
3. Access to water sources and safe sanitation are unsatisfactory, water demand is either not met or mostly met, energy demand is only partially met, and WE resources are becoming less affordable or remaining the same.

When looking at both WEF and the household in the Berg, Keiskamma and uMngeni, we find that greater vulnerability is evident in four groups:

1. Young and small households with one or two incomes (often seasonal or casual) and precarious financial situations; these households are even more vulnerable if they are backyarders paying their main house landlords for monthly rent, water and electricity with little remaining for food.
2. Pensioner-headed small households with one pension and no other income, and increasingly unable to afford WEF.
3. Households of various sizes (some quite large), where the household head is not employed and there are no or few other income contributions from the other household members.
4. 'Water and energy poor' households with rudimentary water and sanitation facilities, widespread use of energy sources other than electricity (even if available), high levels of poverty, and an increasing inability to afford WEF purchases.

Strategies that seem to provide resilience include:

1. The household head earning a stable and good income and able to support even a large family, with improving WEF security (seen mainly in Sobantu).
2. Pensioner-headed large households with multiple additional income sources (seen mainly in Pniel, a community with strong social and family cohesion).

3. Households that have access to land and practice farming or food gardening, and have access to natural resources, such as water for crops and wood as an affordable energy choice (seen in the Keiskamma and to a smaller extent in the upper Berg).

Do these household-WEF situations intersect with livelihood situations? First, the important role of pensions as an income source emerged strongly in the analysis for the Berg and uMngeni sites, even in households where members also earned an income from working. In the Keiskamma, the main household source of income from the two study sites was social grants (80.6%). Pensions and social grants are a very important buffer in the face of precarious livelihoods. There is no direct relationship between a pension or grant and WEF security, except through the declining purchasing power of a pension or grant not keeping up with inflation.

Direct linkages between WEF resources and livelihoods are apparent at specific sites only, including the two Keiskamma communities and the three Berg communities. Within these communities, a proportion of livelihoods relate to livestock keeping or small-scale farming (Keiskamma) or constitute seasonal or casual jobs in agriculture/fisheries (Berg communities). For the former, lack of access to water and land is the main WEF barrier. For the latter, many of these workers are young and recent arrivals living in backyard dwellings. These living conditions are associated with WEF insecurity. Other types of livelihoods (employment in other sectors, more permanent or contractual) do not directly link to household WEF security, as seen across the Berg and uMngeni communities. Rather, level of income and combined household income are more important determinants of household WEF security.

The relationship that local communities have to their local natural resource base varies across catchments and within catchments. The strongest connections are found in the more rural Keiskamma catchment, where households that engage in agriculture were shown to be more energy and food secure. Also, 81% of households use wood for cooking and other purposes as an energy source. This is generally collected in the surrounding environment by harvesters, as their livelihood, and sold to households. Where electricity is not affordable, wood (and also manure) provides a valuable alternative. Wood is also used by 13 Berg households, most of them in Lanquedoc which is semi-rural with wood available in the environment surrounding the settlement. However, only three households in Pniel, in the same area, use wood. In these households, gas is the preferred alternative to electricity. Wood is used in only two households in Noordhoek, which is situated in an environment with very low natural resources of wood. Food gardens are very common in Pniel and Lanquedoc, where the soils and climate are excellent, but much lower in Noordhoek which has poor soils and a harsher climate. Many households in Sobantu and Mpophomeni grow food, but in Melani and Hamburg the proportion is low owing to a lack of water. Foraging for food is limited to a handful of households in Lanquedoc, Mpophomeni and Sobantu. While fishing is practised by 23% of households in Noordhoek on the Berg River estuary, and seafood (mussels) harvesting is done by a group of women in Hamburg, the fish/mussels are preferentially sold.

Drawing on available and significant variables from the Census and the case studies, an index was developed for each of five livelihoods capitals for each community: financial, physical, human, social and natural, linking to WEF resources. The summary spider plot (Fig. 2) highlights the variability between and within catchments. The results highlight complex interactions between catchment-specific physical, human and natural capitals, site-specific social capital, and ubiquitously constrained financial capital (Fig. 2). Overall, the Keiskamma communities have a slightly lower livelihood-WEF index, but the combination of capitals results in similar overall indices for the other five communities. Limitations to this method lie in the valuation of WEF-related natural capital, which decreases in livelihood-related importance as households and communities become more urbanised in emerging economies. The role of social capital requires further investigation in the livelihood-WEF context. Importantly, the impact of political economy and governance challenges may be more important than any direct interlinkages between livelihood capitals and WEF insecurity.

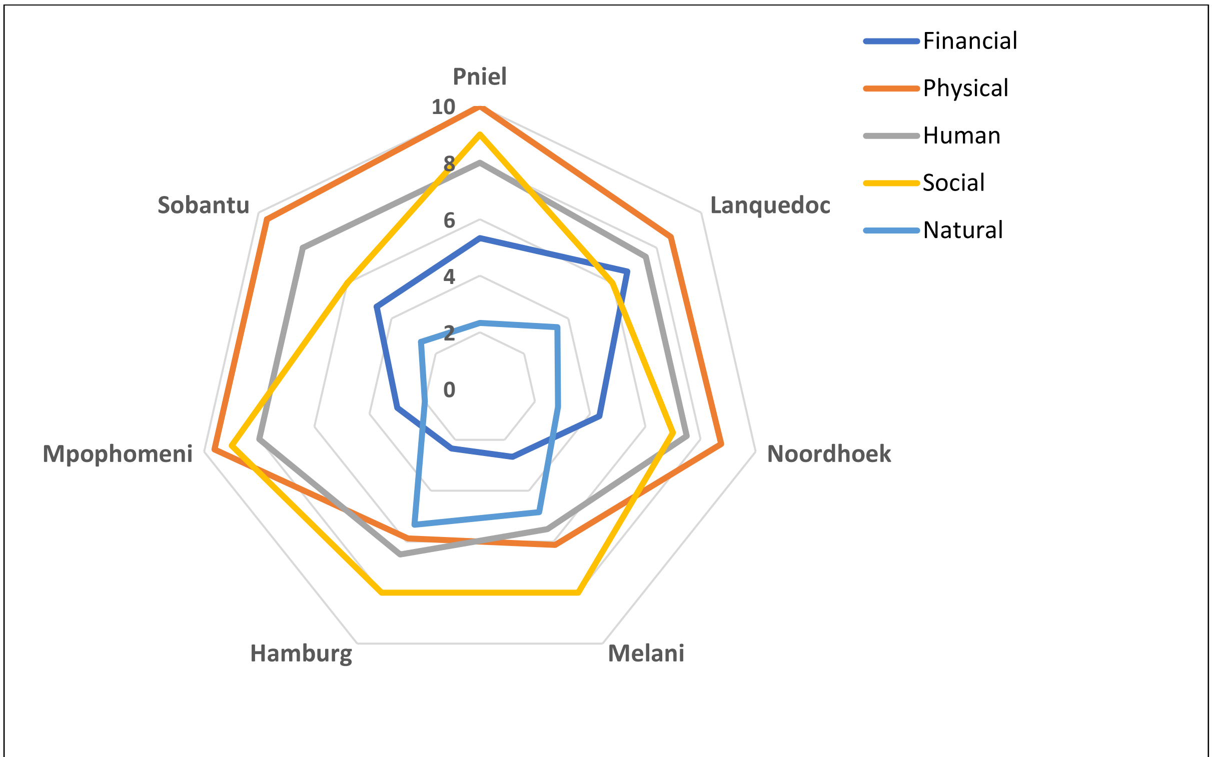

Figure B. Summary of WEF-related livelihoods capitals across the seven communities based on an index developed for each capital.

Adding the governance angle helps to understand the variance of WEF securities across the sites. In the Berg catchment, governance is quite strong, and service delivery is good except for backyard dwellers. Affordability appears to the main problem in all three sites. Newer settlements are behind in the provision of water/sanitation services, and weaker service delivery impacts directly on livelihood securities. WEF trade-offs at household level are minimal and are expressed through substitution in energy sources and a declining food diversity. WEF governance challenges that impact livelihoods could be observed at the level of the main employers in the area, e.g. farms, fish factory, rather than the household level. The uMngeni sites are characterized by a non-payment culture. This community-wide coping strategy has ensured that water and energy are available and accessed, but governance is eroding. Household decisions are, as a result, focused on food security. It appears that WEF governance challenges become visible at the level of regional utilities rather than at the household level. The Keiskamma sites are faced with weak governance structures especially in relation to water/sanitation infrastructure and services. Inadequate access to water and to a lesser extent to energy, together with limited livelihood opportunities are key drivers for WEF insecurities and trade-offs at the household level.

Based on this understanding, we conclude that for all three WEF dimensions, access and affordability are significant barriers in the Berg, Keiskamma and uMngeni communities. Yet, in the Keiskamma communities, availability is an additional significant barrier.

Finally, we summarise the experiences of the youth development and community empowerment aspects of the project. Local partner organisations were identified for all case study sites. The selection was largely informed by the research institutions involved in the study having knowledge of or previous engagement with a local not-for-profit organisation (NPO) in the area. The incorporation of local youth into the project was well received and supported. However, the planned number of one youth per research site was not seen as sufficient given the high unemployment levels among the youth in these communities. The number of youth per site was increased, with the final number (between five and ten) being determined per site according to the context.

Once recruited, the youth were trained in WEF nexus and related concepts, as well as data collection methods, etiquette and ethics. This was achieved through three 'train the trainer' workshops attended by the students conducting the case studies at the specific sites, and in the case of the first workshop, by youth leaders or community representatives from the sites. The trainers then trained the youth in their sites. Once the training was complete, the data collection commenced in pairs, and between 50 and 150 household questionnaires were administered per site. The youth were given a financial incentive to motivate for complete and good quality data collection.

Resource mapping relating to the WEF nexus was done with the youth at most sites to varying degrees depending on the site-specific research needs. At the Noordhoek (Velddrif, lower Berg), Hamburg (lower Keiskamma) and uMngeni sites this included expert-led learning journeys to bulk infrastructure related to water supply and wastewater, as well as to electrical supply infrastructure in the case of Velddrif. These visits not only assisted with mapping the resource systems but were highly informative and promoted an understanding amongst the youth of the bulk systems of supply upon which their communities rely. They also introduced conversations between local youth and municipal officials who manage these systems. The community feedback workshops were designed to ensure that the project findings were communicated back to the participating communities towards the close of the project. These took place at all sites except Velddrif due to protest action around housing allocation.

The youth and community empowerment component provided opportunities but was not without challenges. Opportunities included exposing the youth to academic research; facilitating a rich exchange between local and academic knowledge systems, which improved understanding and the establishment of a common language between the researchers and local youth; and providing experience for the Masters students in training and managing teams of local community research assistants. The approach presented challenges in the form of varying commitment by the youth; varying participation across the partner organisations; and varying quality of the data collected by the youth. Many of these challenges could be avoided by allocating more time and resources to youth development and community empowerment, and by including the communities at the project proposal stage. This would help to identify research questions and activities that they consider important in the context of the WEF nexus and sustainable local development.

Conclusions and recommendations

This study is the first in South Africa to investigate the interconnections between livelihoods and WEF security at household and community level, in underprivileged rural to peri-urban communities across diverse catchments. Several new and policy-relevant insights have been gained.

- The first key finding is that direct interlinkages between livelihoods and WEF insecurity were identified only in the more rural catchment, the Keiskamma in the Eastern Cape. Here, households with access to land for farming are more secure, natural resources (e.g. wood) are widely harvested, and for both energy and water/sanitation, lack of availability (through poor infrastructure and often weak governance) is a barrier.
- In all three catchments, household income and the affordability of water, energy and food are the primary drivers of WEF security, thus constituting indirect linkages. Where income does not cover all WEF needs, households practice substitution using more affordable options, or energy and/or food needs are not met, since water is essential. The uMngeni communities have circumvented this by resorting to non-payment of water and electricity which is bound up with eroding governance of these resources at regional scale. In contrast, well-governed municipal billing systems in Noordhoek reduce the opportunities for substitution or trade-offs to food purchases.
- Household characteristics relating to dwelling type, age and gender of the head, household size and the combined household income explained much of the variability in household WEF characteristics. This finding cut across all the communities.
- Tangible interconnections between livelihoods and the WEF nexus emerged strongly at the town level in the Berg catchment communities. Here, employment in the agriculture and fisheries sectors is strongly influenced by water and energy resource availability, allocation and stability (e.g. drought, load shedding).
- Three types of WEF insecure and vulnerable households were identified. Different solutions are needed for each, with implications for policy development.

- Strategies that provide some livelihood-WEF resilience are mostly community- and catchment-specific, but the two relating to income should be replicable in most communities of South Africa where sustainable job opportunities can be created and maintained.

The research has distilled a few key knowledge gaps regarding the understanding of WEF security at household level. Some of these questions include inter-generational factors that influence family housing situations; income pooling and income buffering through pensions and social grants; and the role of social cohesion. Since livelihoods in the South African context are becoming increasingly disconnected from 'natural capital' as populations urbanise (even in semi-rural communities), the livelihoods capitals could be re-evaluated to better reflect the non-natural assets that play out in providing such livelihoods. We have, through data analysis, identified that income and resource substitution occur in poor households that are unable to afford all their water, energy and food needs. However, a large gap exists in understanding decision-making processes in this regard, covering not only income-expenditure realities but importantly also the role of governance (debt collection, reliable service provision, etc.) in the local (municipal) context.

This project used an innovative research approach by engaging unemployed youth in parts of the research activities. Given that the emphasis was directed towards upskilling and awareness raising, the biophysical nexus dynamics may have not been rigorously captured, but it has created a rich understanding of how communities perceive and experience the interaction of water energy and food in their households and communities. The involvement of the youth has especially helped to understand the various manifestations of social capital in the communities, as well as specific vulnerabilities linked to geographical location and household type.

Future research should concentrate on the following:

- Inter-generational factors that influence livelihood-WEF security relationships at household level.
- A context-specific SLA, including a re-evaluation of livelihood assets for South African households and communities that are increasingly disconnected from natural assets, where social capital rarely translates into political activism, and where stable incomes can no longer be expected to form a key component of financial capital.
- Longitudinal studies on WEF purchasing decision-making at household level to better understand trade-offs within the local WEF governance context.
- Integrated research on alternative or supplemental affordable sources of water, energy and food for households and how strengthened WEF security could support greater livelihood opportunities.
- Studies that apply the intersection of the WEF nexus and livelihoods to the context of municipal-level planning and decision-making, particularly with reference to local economic development where trade-offs between job creation and municipal income streams through service provision could play out.

The study supports policy development and strengthening in the following areas:

- Develop policy focusing on packages of infrastructure rather than dealing with infrastructure sectorally as this will be more effective in poverty reduction, with the caveat that households with access to the infrastructure may still be poor in other dimensions, e.g. nutrition.
- Improve assurance of water and electricity service delivery especially in areas with a high concentration of poor communities through strengthened governance.
- Simultaneously, provide support to poor households to make available more affordable additional water sources such as rainwater harvesting.
- Support for clean and affordable alternative or supplemental energy sources, including rapid scaling up of renewable energy (solar) for household use. De-couple municipal revenue streams linked to water and electricity to create enabling conditions for a transition to a green economy and decentralized supply systems especially in rural and peri-urban areas.
- Improved transparency and accountability on decision-making processes relating to the three WEF resources.
- Local economic development planning that aims for a diversity of job opportunities in the primary, secondary and tertiary sectors, even in ‘agricultural’ or ‘fishing’ areas, since they are vulnerable to water and energy supply and pricing issues which can put livelihoods at risk.
- Create an enabling environment for local enterprise development that leads to a wide choice of income generating opportunities that together can contribute to household income diversification and combined income, and thereby WEF security.

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Contents

List of Tables

List of Figures

Abbreviations and Acronyms

ACDI	African Climate and Development Initiative
ADM	Amathole District Municipality
BRM	Bergrivier Local Municipality
CBO	Community Based Organisation
CCT	City of Cape Town
CRA	Community Research Assistant
DWS	Department of Water and Sanitation
ELS	Environmental Livelihood Security
EPWP	Extended Public Works Programme
IDP	Integrated Development Plan
IDZ	Industrial Development Zone
IWRM	Integrated Water Resources Management
KZN	KwaZulu-Natal
NGO	Non-Governmental Organisation
NPO	Non-Profit Organisation
SDG	Sustainable Development Goal
SLA	Sustainable Livelihoods Approach
WCDM	West Coast District Municipality
WCWSS	Western Cape Water Supply system
WE	Water Energy
WEF	Water-Energy-Food
WRC	Water Research Commission

CHAPTER 1 INTRODUCTION

1.1 Background and rationale

Essential natural resources such as water, arable land and biodiversity assets are being over-exploited and degraded in many parts of the world, necessitating the move towards an integrated approach to natural resource management (Rockström et al., 2009; Vörösmarty et al., 2010; Scott et al., 2015; Cole et al., 2014). The Water-Energy-Food (WEF) Nexus is a framework that captures the inter-relations, synergies and trade-offs between the demand and supply of water, energy and food, in the context of the emerging constraints of sustainable development in particular regions or systems (Hoff et al., 2011; Scott et al., 2015). Using the socio-ecological system as a primary point of reference, nexus thinking has gained recognition within the scientific community and among policy makers and development institutions at global and national levels (e.g. ODI-ECDPM-DIE, 2012; FAO, 2014; UNESCWA, 2015; Rasul, 2016).

The WEF nexus is argued to be valuable for understanding interlinkages and feedbacks within complex systems, and for decision-making to achieve macro-scale sustainable development (Weitz et al., 2014; Gallagher et al., 2016; Mohtar, 2016). The nexus approach was adopted for the global risk report of the World Economic Forum (WEF, 2011), and has informed the development of the Sustainable Development Goals (SDGs) (United Nations, 2015). The WEF nexus was factored in as part of SDG 2 (zero hunger), 6 (clean water and sanitation) and 7 (affordable and clean energy) with indirect potential to help achieve several other SDGs (Lawford et al., 2016; Mpandeli, 2017; Mabhaudhi et al., 2019; Nhamo et al., 2019). However, the nexus has until recently placed its emphasis at the global level and large infrastructure expansions, while overshadowing challenges which are faced by minor players such as households, small businesses and communities at grass-root level (Terrapon-Pfaff et al., 2018). The conceptual and methodological development of the nexus approach at this scale remains weak and not convincingly applied in practice. In the South African context, a deeper understanding is needed of how the nexus framework can assist in building livelihood resilience across the socio-economic spectrum, and in shifting towards a sustainable economy (Mpandeli, 2017; Mabhaudhi et al., 2018, 2019; Nhamo et al., 2018).

South Africa has adopted various integrative polices to move towards a more sustainable economy; yet, on the ground, unsustainable patterns of resource use persist from local to national scales (Schreiner and Hassan, 2010; Knüppe and Pahl-Wostl, 2013; Cole et al., 2014). As a result, water, energy and food security can be compromised, with serious implications for the long-term development of South African communities and individual households (von Bormann and Gulati, 2014). For the most part, the costs of unintended nexus trade-offs are paid by the most vulnerable communities because of their limited means to influence higher levels of decision-making and frequent lack of capacities to mediate (or take advantage of) changing nexus dynamics (ODI-ECDPM-DIE, 2012).

While livelihoods have been studied and conceptualized in several ways and disciplines, the Sustainable Livelihoods Approach (SLA) is one of the most sophisticated and well-established frameworks for analysing and understanding livelihoods and the consequences of resource insecurities at the household level (Small, 2007). In SLA studies, access to financial, social, human, natural and physical livelihood assets (the five capitals) are investigated in relation to the context of that livelihood (e.g. climate, demography, history and macro-economic conditions), institutional processes (e.g. organizational arrangements and land tenure), and the livelihood strategies that are used (combinations of activities people choose to undertake to achieve their livelihood goals) (Scoones, 1998; Reed et al., 2013). While the SLA can and should conceptually accommodate multiple scales of biophysical and socio-political context, the debate and practical use of SLA in development work has for the most part not gone beyond the household and 'capitals' level.

The question thus arises as to whether a conceptual linking of the WEF nexus with the SLA would enable a deeper understanding of the multi-scalar relationships and how they play out for households and communities (Mpandeli, 2017). Would a combined approach address the shortcomings of each while providing for improved cross-scale linkages from global to local? The Environmental Livelihood Security (ELS) framework is an attempt by Biggs et al. (2015) to combine concepts of the WEF nexus with the capitals / assets of the SLA. The assumption is that, to achieve environmental livelihood security, a sustainable balance between natural resource supply and human resource demand needs to be achieved. Unfortunately, the ELS framework focuses primarily on the five capitals, while less attention is given to issues of power and social differentiation or relational issues, e.g. how different social groups relate to their local ecosystems. There is thus an opportunity to evaluate the merits and demerits of a combined nexus-SLA framework that takes a more contextualized view of livelihoods with incorporation of non-resource-based capitals and assets that are pivotal for households and key to the development of livelihood policies and their implementation.

More recently, Mabhaudhi et al. (2019) adapted the WEF nexus analytical model of Nhamo and co-authors (Nhamo et al., 2019) to develop a WEF analytical livelihoods framework (ALF). The ALF also aimed to serve as a tool for assessing the performance and progress of SDG 2, SDG 6 and SDG 7. While conceptually focused on livelihoods, the analysis nevertheless relies on national level indicators (Nhamo et al., 2019) and data. The paper, overall, is aligned at an even larger scale, namely, Southern Africa, so that the household scale is not visible. The authors acknowledge the problem by stating (Mabhaudhi et al., 2019:16): "The analysis highlighted the gap in data availability at the household level, thus this study focused on regional level analyses. Future studies should focus on the household scale analyses as this will translate to greater impact."

This project, 'Exploring the Evidence of Water-Energy-Food Nexus Linkages to Sustainable Local Livelihoods and Wellbeing in South Africa', aimed to fill the identified knowledge gap, exploring how the nexus plays out in affecting local livelihoods, and how this understanding can support more equitable sustainable development outcomes at the household level. The project is based on three avenues of research to understand this:

i. systematically interrogating and integrating the existing nexus and sustainable livelihoods literature, which has not previously been done;
ii. empirical research (ground testing using the household resource modelling approach) on the nexus at the household scale in three catchments in different provinces in South Africa, identifying household resource insecurities and the effects thereof on livelihoods; and
iii. analysis of the governance arrangements and decisions made at various higher levels that lead to the current local scale nexus situations and trade-offs, and identification of key opportunities for employing local solutions to relieve nexus stress and thus improve livelihoods, and in the broader nexus governance processes.

This project is an early contribution to the WRC's Water-Energy-Food (WEF) Lighthouse 3 Initiative, which is specifically focused on:

a. improving water, energy and food security;
b. supporting the transition to a low-carbon economy and sustainability; and
c. understanding the interdependencies of food, energy and water resource systems.

The project is a response to the need to capture and reflect lessons learnt from WEF nexus research internationally and nationally. It furthermore collected original data and trialled various methodologies for analysing nexus issues in South Africa. Importantly, the project critically examined the WEF nexus approach from a sustainable livelihoods framework, to ensure that it is appropriate for delivering sustainable development outcomes for the ultimate target beneficiaries: local households and communities. More specifically, the project is an opportunity to test, advance and extend the approach upon which the WEF Lighthouse Initiative builds going forward.

1.2 Scope and Purpose

1.2.1 Linking the nexus to the local scale/ level

The WEF nexus concept, which focuses on the interdependencies between the production and use of the water, energy and food (Hagemann and Kirschke, 2019), has brought to the fore that water, energy and food securities are intrinsically linked. "To explain the nexus in its simplest form, water is needed to generate energy, energy is needed to supply water, energy is needed to produce food, food can be used to produce energy, water is needed to grow food, while food transports (virtual) water, often using energy" (Stringer et al., 2019:903). Changes to any one of the resources can have knock-on implications for the remaining two across a range of scales (Hussey and Pittock, 2012). Countries that want to improve the lives and well-being of their citizens and make strides in achieving the SDGs such as SDGs 2 (zero hunger), SDG 6 (clean water and sanitation) and SDG 7 (affordable and clean energy) will have limited success if WEF interlinkages and cross-scale interactions are not seriously considered in development planning whether it is at the national or local scale. "The nexus approach aims to identify trade-offs and synergies of water, energy, and food systems, internalize social and environmental impacts, and guide development of cross-sectoral policies" (Albrecht et al., 2018:1). Indeed, it has been argued that the WEF nexus approach could potentially facilitate the integrated achievement of SDGs (Bleischwitz et al., 2018; Ghodsvali et al., 2019; Mabhaudhi et al., 2019; Pahl-Wostl, 2019). Although the WEF nexus reflects mainly on interconnections between SDG 2, 6, 7 there are several direct and indirect linkages between nexus thinking and other SDGs (Pahl-Wostl, 2019).

Nexus thinking is based on a strong systems perspective and has highlighted the importance of unpacking the interdependencies of water, energy and food across scales and levels (McGrane et al., 2019). The concept has been valuable for understanding complex systems and for enhancing integrated planning across policy fields and academic disciplines to achieve macro-scale sustainable development (Lui et al., 2019; Simpson and Jewitt, 2019).

Missing, however, from the scientific and political debates, is a focus on the major nexus challenges faced by the poor at local, community and household levels (Terrapon-Pfaff et al., 2018). While many authors have highlighted that the WEF nexus is crucial for households and communities – in the rural and urban context (Leck et al., 2015; White et al., 2017; Mabhaudhi et al., 2019), Biggs et al. (2015) rightfully point out that this livelihood level has for the most part not been part of the nexus research. Few studies have been conducted at the household or community scale (Terrapon-Pfaff et al., 2018; Villamore et al., 2018; Jaka, 2019), assessing household WEF security and how it is shaped by policies, institutions and knowledge types operating at larger scales (Allouche et al., 2014; Stringer et al., 2019). It is, therefore, not surprising that major nexus challenges faced by the poor at local, community and household levels remain unacknowledged and not adequately addressed.

The historical emphasis of the nexus approach on the global or transboundary scale, together with the development of mostly quantitative methods and tools, contributes to an explanation of why there appear to be so few studies of nexus dynamics and implications for livelihoods at local level. The lack of attention to social justice and equity (in terms of social, economic and environmental outcomes) in the current nexus debates is therefore not surprising. The focus remains on optimisation and efficiency in the context of WEF scarcity, through policy coherence (Weitz et al., 2017; Stringer et al., 2019). Several authors (e.g. Leck et al., 2015; Allouche et al., 2015; Larcom and van Gevelt, 2017; Wiegleb and Bruns, 2018) have emphasised the need for the political economy of the nexus to be more explicitly addressed, drawing attention to the manner in which power and vested interests control and influence resource allocation processes.

In this project we set out to explore how the WEF nexus concept can be translated into practical nexus assessments at the local level (household and community). Through this explorative inquiry we furthermore would like to contribute to an understanding of what is needed to utilise the nexus concept as a framework for informed decision-making that leads to more equitable and sustainable development outcomes at household and community level.

For our WEF nexus assessment at the local scale we have developed a framework (Fig. 1) that focuses primarily on the household level but acknowledges that other scales need to be considered (see Mabhaudhi et al., 2018) in order to understand how the interdependencies of water, energy and food (at various scales) affect the utilisation of these resources at household level.

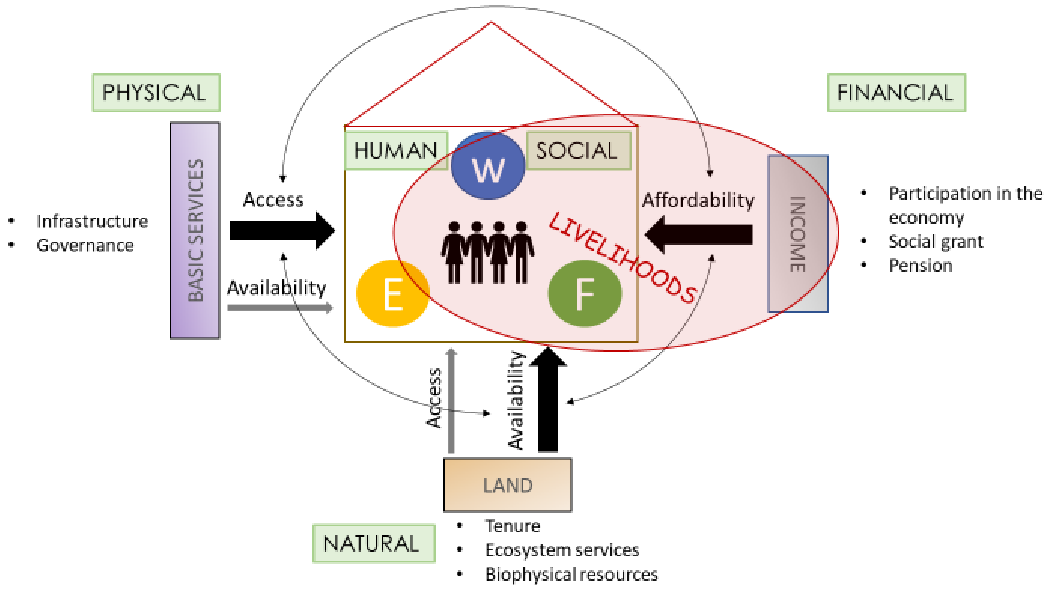


Figure 1 Conceptual diagram of the WEF nexus at household level intersecting with livelihoods, illustrating the components considered in this study.

Households use and to a certain extent produce WEF to meet their basic human needs and to engage in specific livelihoods activities. To be able to determine how availability, access, and affordability affect the utilization of the individual resources as well as their interplay we have included three additional components into our framework, namely land, basic service delivery and income.

Land (defined here as any parcel of land within easy access of the home that can be used for home gardening, growing of woodlots, keeping of household livestock or various types of farming) is a key component that needs to be included when discussing the nexus at the household level. The land component also acknowledges biophysical constraints (soil quality, water yield) as well as the feedbacks that exist between household activities and the state of the local ecosystem, including ecosystem services. Furthermore, considering South Africa's colonial and apartheid legacy, access to water cannot be discussed without discussing access to and ownership/tenure of land.

Another important component that determines access to water, energy and to a lesser extent food is the **provisioning of basic services** through the South African state. The presence, choice and maintenance of infrastructure are critical to access, and to a lesser extent to availability, of these resources. Also critical are coordination and informed decision-making across government levels.

Income determines whether a household can afford the resources and services (through purchasing or producing). Income can be generated through the active participation in the local/regional economy, through social protection by the state in form of social grants, and/or through various types of pensions.

In our conceptualisation we also acknowledge the complex interlinkages between local communities, industry and agriculture. While these domains often compete directly for water, energy and land, local industries and agricultural enterprises can provide household members opportunities to engage in income generating activities. For assessing the impacts of the WEF nexus on livelihoods, not just in terms of household securities, we highlight in the framework the reciprocal interaction between income and household through a red circle.

Important to note is that trade-offs and scarcities experienced at household level are often linked to nexus pressures and / or decision-making processes at higher scales. To deal with **the scale issue** we focus on two dimensions of **embeddedness**. Our conceptualisation incorporates the consideration of the larger socio-ecological systems within which local livelihoods are embedded by using the catchment areas as another important scale. This allows us to explore upstream and downstream interlinkages as well as the communalities and differences between rural vs urban communities. Furthermore, households do not operate in isolation but are embedded in communities. The nature of social relations and presence of social cohesion in these communities can often influence how households interact with the three resources.

1.2.2 Strengthening nexus understanding through transdisciplinarity

Ghodsvali et al. (2019:266) state that "although the concept of transdisciplinarity has been widely accepted by nexus research, an explicit cognition of its practicability in real-world is still lacking, and sophisticated methodological development is required." Building on the definition provided by Lang et al. (2012:26-27) we refer to transdisciplinarity as "a reflexive, integrative, method driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge". The inclusion and training of unemployed youth from the research sites as community research assistants (CRAs) speaks to this definition and provides opportunity for co-production between the researchers and the youth of the study sites. Unemployed youth, as a category, were specifically targeted for inclusion in the project due to the high rates of unemployment amongst the youth in South Africa. It was envisaged that through knowledge exchange, upskilling and exposing the youth to topics that may be novel and interesting for them, it would provide stimulation, new skills, foster broader perspectives and build confidence – all of which it is hoped will assist them to get closer to generating a sustainable income. In addition, by including youth, it provides an opportunity for knowledge exchanges between academic and local knowledge systems, which has the possibility of introducing new perspectives, developing common language and improved understanding amongst researchers and non-academics alike. This in turn can assist in surfacing how the WEF nexus materializes at the local scale and how people's livelihoods are affected by the interdependencies and interactions of these three resources while at the same time giving voice to contradictions and vulnerabilities that are not easily surfaced through census data and disciplinary research. For different knowledge systems to be recognised and surfaced requires mutual respect and value systems able to transcend prevailing knowledge hierarchies.

In addition, co-production is an excellent vehicle for bringing different perspectives together, stimulating social learning processes and developing practical solutions to context specific development issues. Gaining expertise and skills in the transdisciplinary work is also of value for the Masters students who may in the future be working in complex environments that require the integration of multiple knowledge sources and systems in order to address the drivers of prevailing sustainability and equity problems. Throughout the project the team have endeavoured to interpret and apply the theory cited above. This has resulted in the meeting of theory and practice, of academic research and non-academic lived experience, as well as of researchers and non-academics alike. In addition, it must be noted that the project design within which this transdisciplinary research takes place spans three universities, each with a student and supervisory staff trained in various disciplinary fields, three catchments located in three provinces, with two research sites per catchment.

Trialling this approach across this span has provided some key insights that hopefully will be useful to future projects wishing to take up this approach. These include:

- The inclusion and training of unemployed youth as CRAs is worth replicating. The value-add to the youth in terms of upskilling, earning a small income (stipend), growing their confidence and providing mentorship and access to the research spaces they are most often than not excluded from, was invaluable. Given the scale of the youth unemployment problem in South Africa, every effort should be made to contribute towards improving the situation. The transdisciplinary approach lends itself to the inclusion of non-academic actors, specifically when the research involves communities.
- The inclusion of local youth from the communities involved in the research also assists the researcher in that it brings in local knowledge and lived experience, thus deepening the research knowledge base.
- The WRC is well placed to foster this approach in appropriate research projects, particularly given that it will expand the local community knowledge base regarding water related research and outputs. An expanded understanding of some of the issues being dealt with in the water sector will contribute to better management and use of the water resource.

1.3 General aim and specific objectives

The project has the overarching aim of providing foundational and ground-tested evidence that can inform community development and empowerment as well as the WRC Lighthouse theme on Water-Energy-Food Security, and to identify knowledge gaps so as to inform the direction of future WEF Nexus research to support equitable sustainable development.

Specific research objectives:

1. To conduct a systematic review of the evidence on the WEF Nexus at different scales, with a focus on how the nexus affects livelihoods at household and community level.
2. To use case studies in catchment areas that span rural and urban communities to explore how the WEF Nexus plays out 'on the ground' and mediates the livelihoods of different actors at the local scale; specifically, with reference to how they are embedded within river catchments and their associated governance systems for water, energy and food. This will be done by trialling a household resource modelling approach.
3. To strengthen awareness of Nexus thinking for integrated development planning and natural resource management at different scales amongst decision-makers, and extract recommendations for policy as well as research in order to move into an era of informed decision-making.
4. To identify key knowledge gaps in the interplay between WEF Nexus and development that will need to be answered by longer-term research projects.
5. To trial a process of involving and up-skilling local youth together with their communities, thus empowering them to better understand how the Nexus impacts on their financial outcomes and economic opportunities.

CHAPTER 2: KNOWLEDGE REVIEW

TOWARDS A BETTER UNDERSTANDING OF WEF NEXUS LINKAGES AND SUSTAINABLE LIVELIHOODS

2.1 Introduction

This study responds to the first specific research objective, namely, "To conduct a systematic review of the evidence on the WEF Nexus at different scales, with a focus on how the nexus affects livelihoods at household and community level." The aim is to provide guidance on whether future studies could better capture and help to put into practice the linkages, both explicit and implicit, between nexus issues and local socio-economic development outcomes. Further, we aim at deepening the understanding around relational issues and the embedded aspects of the nexus as well as livelihoods. We conduct the study in two parts:

First, we probe the literature for evidence of the conceptual and practical utility (or not) of a combined WEF nexus-SLA framework in the context of sustainable development at grass-root level. We do this by posing the following questions:

- Where are the intersections between the WEF nexus and livelihoods and how do they impact on one another?
- What are the benefits of a livelihoods focus for nexus study?
- What are the benefits of a nexus lens for livelihoods analysis?
- What can a combined WEF nexus-livelihoods approach tell us about risks and vulnerabilities of communities and impacts on achieving sustainable development?

Second, we complement the comparative assessment with an investigation into the evidence base on nexus-livelihood linkages at household and community level. We discuss four key papers identified during the review as useful examples for advancing studies capable of increasing the empirical evidence and understanding of how the WEF nexus at different scales intersects with livelihoods. The selected papers have either successfully been able to provide insights into nexus-livelihood linkages or they have the potential to do so because of their innovative methods.

The review is structured as follows. We begin by providing an overview of the two approaches, WEF nexus and SLA (section 2.2). In section 2.3 we describe the methods and criteria used to select and interrogate articles for the review of WEF nexus-livelihoods linkages. The results of the review are presented in section 2.4. First, we highlight key points regarding the compatibility of the nexus approach and the SLA (section 2.4.1). We then discuss the findings of the empirical evidence of nexus-livelihoods linkages drawing on four selected studies (section 2.4.2). Finally, in section 2.5 we return to the guiding questions raised in the introduction and reflect on whether a combined framework would be potentially impactful in practice for improved livelihood outcomes.

2.2 Overview of the WEF nexus approach and the SLA

The FAO (FAO, 2014:3) states that "[the Water-Energy-Food nexus] presents a conceptual approach to better understand and systematically analyse the interactions between the natural environment and human activities, and to work towards a more coordinated management and use of natural resources across sectors and scales. This can help us to identify and manage trade-offs and to build synergies through our responses, allowing for more integrated and cost-effective planning, decision-making, implementation, monitoring and evaluation." Increasingly, economic development decisions are coming face to face with trade-offs and the need to seek greater efficiencies of resource use. Pressure on resources could eventually result in shortages and lead to greater risks of food, energy and water insecurity. As solutions are sought, resource-linked decisions made in favour of one of these sectors can either help or harm the other sectors. When these trade-offs are identified and quantified, decisions can be adapted, or mitigation measures put in place to optimize overall benefits. Albrecht et al. (2018) found that the nexus approach has most frequently been used to improve resource use efficiency or management, to identify policy incongruences and enhance policy integration, and to promote sustainable resource use practices.

The initial debate around the nexus at the Bonn Nexus Conference in 2011 drew on several discussion documents and a proposed conceptual framework based on the dimensions water, energy and food and their interlinkages (Hoff, 2011). The nexus approach has since been broadened to include other dimensions within a more comprehensive analytical framework (Scott et al., 2015), with frequent inclusion of land, ecosystems and climate as equal dimensions, or central drivers of nexus dynamics (e.g. Ringler et al., 2013; Conway et al., 2015; Smajl et al., 2016). In South Africa, two WEF nexus frameworks have been proposed. Midgley et al. (2014) focused on the catchment scale with incorporation of land and biodiversity in addition to water, energy and food. Mabhaudhi et al. (2018) in their nexus framework emphasised the linkages to the SDGs at national scale. The proliferation of different conceptualizations in a short time points to a fundamental interest in the nexus approach, but a lack of agreement on the scope, objectives and understanding of the dimensions, their interactions and the contextual drivers and pressures. For this reason, the WEF nexus approach remains largely theoretical, with a few exceptions where specific framings have been applied to local case studies (e.g. Bromwich, 2015; Jalilov et al., 2013, 2016; Ramaswami et al., 2017). From a sustainable development perspective, the conceptual linkages to sustainable livelihoods remain under-explored (Lawford et al., 2016).

In line with Ellis (2000), we regard a livelihood as that which comprises: "… the assets (natural, human, financial, social, and physical capital), the activities, and the access to these (mediated by institutional and social relations) that together determine the living gained by the individual or household." Olsson et al. (2014:798) highlight that "a livelihood lens is a grounded and multidimensional perspective that recognizes the flexibility and constraints with which people construct their complex lives and adapt their livelihoods in dynamic ways". The concept of sustainable livelihoods emerged in the 1990s in response to the failure of dominant development theories to pay attention to factors and processes which constrain or enhance poor people's ability to make a living (Donohue and Biggs, 2015). A "livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base" (Scoones, 2009:175). Sustainable livelihoods approaches (SLAs) assume that poverty is not just about a shortfall in income, but "seeks to transcend Western conceptions of 'making a living'" (Connell, 2010:353). Since the original conceptualization of the SLA by Chambers and Conway (1992), several frameworks have been developed (Scoones, 1998; Carney, 1998; DfID, 1999; Ellis, 2000) and elaborated upon (e.g. Schreckenberg et al., 2010; Kumar et al., 2011).

It is widely understood that both the assets and the strategies which a person or household can implement are filtered by the institutional processes and structures as well as the vulnerability context, i.e. existing shocks and stressors (FAO, 2002; Biggs et al., 2014). Policies and institutions often mediate access to specific assets and have the potential to reduce vulnerability to shocks and stressors (DfID, 1999). The more vulnerable a person is to different shocks and stresses, the more limited in his/her choices he/she will be (limited agency). Thus, it is not sufficient to only address issues of access to resources and basic services such as water, food and energy; attention must also be paid to the embedded dimensions of livelihoods within the community and the linkages between people and their local ecosystems/landscapes at various scales. The interdependency of livelihood activities and ecosystem services/natural resource base is acknowledged in the SLA through the assets belonging to the natural capital as well as the vulnerability context (in the context of natural disasters). There is a clear understanding that livelihood activities can either deplete or degrade the natural resource base (e.g. through the destruction of wetland areas for housing or agricultural purposes), or they can maintain and enhance it (e.g. through sustainable agricultural practices) (e.g. Chambers and Conway, 1992; Kumar et al., 2011; Biggs et al., 2014). Furthermore, the sustainability of livelihoods is not only considered in terms of social sustainability, i.e. the ability to maintain a decent and adequate quality of life now and in the future, but also in the context of the importance of maintaining the resource base upon which future livelihoods will depend (Biggs et al., 2014; Wang et al., 2017; Wolde et al., 2020). These considerations are pertinent for addressing the institutional and relational arrangements within the system.

2.3 Materials and methods

Our interrogation of the literature for evidence of the conceptual and practical utility of a combined WEF nexus-SLA approach was informed by peer reviewed contributions from the WEF nexus scholarship and the sustainable development field. The focus was on those contributions closely linked to the SLA. An initial search of the literature was performed using Scopus. The search was restricted to academic articles, review articles, articles in press, and conference papers. The query was primarily limited to the titles, abstracts, and keywords of articles. For all searches, empirical, theoretical or conceptual articles were considered potentially relevant. While the search of the nexus literature was restricted to the period between 2011 and 2018, the search of the sustainable livelihoods literature did not have such time restrictions since this field of study dates back for several decades.

For the initial investigation as to what extent the WEF nexus scholarship can provide insights into the linkages between the nexus and livelihoods we used the following combination of search terms in Scopus:

- nexus AND livelihoods
- (nexus AND food AND water AND energy) AND livelihoods
- (water AND energy AND food AND nexus AND) sustainable livelihoods
- water AND energy AND food AND nexus AND sustainable development goals AND livelihoods

We then aimed to gain a better understanding of the extent to which the WEF nexus or components thereof are discussed in sustainable development literature focusing on livelihoods. We used the following search terms in Scopus:

- (livelihoods) AND (water security) OR (water insecurity): total 75 papers
- (livelihoods) AND (food security) OR (food insecurity): total 2174 papers
- (livelihoods) AND (energy security) OR (energy insecurity): total 44 papers
- (livelihoods) AND (energy) AND (food) AND (water)): total 117 papers

The resulting set of papers was screened visually by (i) title, (ii) key words, (iii) abstract, to identify a core set of original research, conceptual and review articles, that would serve our research aims. We were also guided by the citations in Biggs et al. (2015) and papers that had cited Biggs et al. (2015) since this was the only published conceptual paper at the time to attempt to combine to WEF nexus and the SLA. The literature gathered was not subjected to further systematic analysis; rather, we took a qualitative approach to assessing the compatibility of WEF and the SLA by focusing our analysis (although not exclusively) on a set of papers as shown in Table 1.

From the articles in Table 1 we then selected four empirical articles that show the potential to explore nexus-livelihoods linkages due to their innovative methods. It should be noted that these articles do not reflect the full scope and breadth of available studies; rather, they should be seen as potentially providing direction for future academic inquiry into nexus-livelihoods intersections.

Selection of the four articles was based on the following criteria:

- The studies were in clearly demarcated localities, usually within a specific river basin or sub-basin or around a key water body, for example; we were also interested in the importance of scale when linking the nexus to livelihoods, so that articles focusing on a diverse range of scales were chosen;
- The researchers conducted a WEF nexus study in the context of livelihoods, either explicitly using both nexus and livelihoods methods, or using nexus methodology with explicit linking to the livelihood outcomes of nexus-based planning for the area;

- The researchers showed clearly how the WEF nexus is interlinked with livelihoods either as an explicit aim or as a main outcome;
- Lessons around strengths and weaknesses in linking nexus and livelihoods approaches were clearly demonstrated and extractable.

Table 1 Key papers used for assessing the compatibility of the WEF nexus and the SLA.

	Key research / conceptual articles	Review articles
WEF	Hoff, 2011 Ringler et al., 2013 Allan et al., 2015 Allouche et al., 2015 Biggs et al., 2015 Foran, 2013, 2015 Halbe et al., 2015 Karlberg et al., 2015 Keskinen et al., 2015 de Strasser et al., 2016 Gallagher et al., 2016 de Grenade et al., 2016 Rasul, 2016 Smajgl et al., 2016 Yillia, 2016 Al-Saidi and Elagib, 2017 Johnson and Karlberg, 2017 Kurian, 2017 Liu et al., 2017 Pahl-Wostl, 2017 Spiegelberg et al., 2017 Bijl et al., 2018	Bazilian et al., 2011 Scott et al., 2015 Wichelns, 2017 Albrecht et al. 2018
SLA	Scoones, 1998 Carney, 1998 DfID. 1999 Ellis, 2000	Small, 2007 Scoones, 2009 Reed et al., 2013 Biggs et al., 2014 Sakdapolrak, 2014 Olsson et al., 2014 Scoones, 2015

The key characteristics of the four selected articles that were used for this study are presented in Table 2.

Table 2 The four papers selected for a more in-depth analysis of nexus-livelihoods linkages in specific communities situated in nexus-stressed basins or sub-basins.

Authors	Title	Aim	Approach	Spatial scales	Nexus component	Livelihoods comp.
Spiegelberg et al. (2017)	Unfolding livelihood aspects of the water-energy-food nexus in the Dampalit Watershed, Philippines	The paper aims to yield policy relevant results to improve the status of the water resources and food products and to reduce possible user conflicts in the Dampalit watershed.	Surveying 176 households mainly in the mid- and downstream areas, elements and interlinkages of the local water-energy-food nexus were identified by the five capitals of the sustainable livelihood approach through a socio-ecological network analysis.	Households, in mid- to downstream areas of the watershed	Ecological system of production, e.g. household water and fuel choices Food products, e.g. food acquisition, consumption, avoidance; food destinations; food origin	Farmers (upland) and fishers (downstream) and sellers Links within social groups of farmers and fishers Direct links between fishers and farmers
Foran (2015)	Node and regime: interdisciplinary analysis of water-energy-food nexus in the Mekong region	By emphasising the need for more vigorous thinking around the political economy of energy, water, and food linkages, the essay aims to redirect applied research work on the resource nexus.	Interdisciplinary analysis of the Mekong resource nexus, based on a critical re-examination of findings based on complex systems thinking. It argues that critical social sciences offer important contributions, potentially in synergy with the dominant complex systems approach to thinking about the nexus.	Greater Mekong region. Case study of regional development initiatives (hydropower dams, water diversion, adaptation to sea-level rise, rubber expansion, railway expansion, bauxite mining and possible alumina production)	Critical social science of the nexus. The power relations that underpin a given resource nexus. Analysis of development initiatives focusing on (i) water, (ii) food security, (iii) energy system, amongst others	Analysis of development initiatives focusing on (iv) livelihoods and migration

Authors	Title	Aim	Approach	Spatial scales	Nexus component	Livelihoods comp.
Keskinen et al. (2015)	Water-energy-food nexus in a transboundary river basin: the case of Tonle Sap Lake, Mekong River Basin	The study aims to increase the understanding of the Tonle Sap system and its future development in the context of the transboundary water-energy-food nexus well as climate change.	Detailed, cumulative assessment of the impacts of hydropower development and climate change on the Tonle Sap as well as a trend analysis of key demographic and socio-economic indicators using the Population Census for years 1998 and 2008. Special attention was paid to the policy relevance of the research results.	Local scale (Tonle Sap area, 3 spatial zones) – water resources, food security, trends in demography and livelihoods National scale – impacts through the hydrological system Transboundary / regional scale (upstream) – hydropower development and climate change	Water: local scale (food security); national scale (hydrological system); regional scale (hydropower, climate change) Food: local scale (food security) Energy: local scale (hydropower); regional scale (hydropower, climate change)	Local scale: fishing and agriculture (livelihoods and food security analysis) The paper has a strong emphasis on livelihoods analysis in the local to wider context.
Karlberg et al. (2015)	Tackling complexity: understanding the food-energy-environment nexus in Ethiopia's Lake Tana Sub-basin	The paper evaluates and compares the impacts of alternative development trajectories pertaining to agriculture, energy and environment, with a focus on current national plans and accounting for cross-sector interlinkages and competing resource use: the food-energy-environment nexus.	Applying a nexus toolkit (WEAP and LEAP) in participatory scenario development, the study compares and evaluates three different future scenarios. The analysis focused on (i) agricultural intensification and transformation, (ii) energy systems transition.	Sub-basin – participatory scenario analysis National – development planning for energy and agricultural sectors.	Scenarios: (i) business as usual; (ii) national plans; (iii) nexus	Subsistence agriculture – crop production and livestock, fishing, wood and papyrus reed harvesting, etc. Analysis focused on divergent impacts on livelihoods under various scenarios, including the nexus scenario.

2.4 Results

2.4.1 Compatibility of the WEF nexus approach and the SLA

An analysis of the compatibility of the two approaches is warranted because it can assist in developing recommendations on how investigations into the macro scale (nexus issues and dynamics) and the micro scale (livelihoods resilience) of sustainable development can be successfully combined. Based on all papers found, an analysis regarding strengths and weaknesses has been carried out. This was done to understand their performance better in the context of sustainable development outcomes.

2.4.1.1 Strengths and weaknesses of the WEF nexus approach in the context of sustainable development

The nexus is understood to potentially provide a robust framework for the exploration of complex cross-sectoral inter-dependencies and dynamics between the WEF components, across multiple scales in local, regional and transboundary settings (De Grenade et al., 2016; Rasul, 2016; Al-Saidi and Elagib, 2017; Bijl et al., 2018). De Grenade et al. (2016:16) state that “the strength of nexus research lies in its reliance on an integrative approach to scholarship and policy development”. It lends itself to the analysis of trade-offs and synergies created by competing resource uses related to food, energy and water security (De Grenade et al., 2016; Nhamo et al., 2019). Furthermore, the proliferation of various versions of the nexus conceptual framework is an indicator of the concept’s inherent flexibility and adaptability to the questions and contexts at hand (De Strasser et al., 2016). However, this could also be seen as a weakness.

In comparison with previous integrated approaches, for example Integrated Water Resources Management (IWRM), the nexus goes beyond a water-centred approach (Benson et al., 2015; Muller, 2015; Giupponi and Gain, 2016) or a food- or energy-based approach, by considering the different dimensions of water, energy and food equally (FAO, 2014; Smajgl et al., 2016). In a relatively short time, the nexus approach has changed or influenced policy debates globally, for example by informing the formulation of the SDGs by United Nations organizations (e.g. FAO, 2014; UNECE, 2014; UNEP, 2014; UNESCWA, 2015) and other institutions in the field of natural resources management and sustainable development, e.g. WEF, 2011; IISD (Bizikova et al., 2013); SEI (Hoff, 2011); IAEA, 2009; ADB, 2013; GIZ and ICLEI, 2014; WWF-SA, 2017; and IUCN (Ozment et al., 2015). Its ability to generate political will and action has come to the fore (Ringler et al., 2013; Liu et al., 2017). It is also widely framed as a useful planning- and decision-support tool (e.g. Bizikova et al., 2013).

Pahl-Wostl (2017:10) provides this assessment of the value of the Nexus: “The Water-Energy-Food nexus supports a reframing of the problem perspective and could support more balanced negotiations of interests between sectors and engage diverse actors. It shifts the emphasis onto relationships and feedbacks between sectors, even if when doing so does not yet solve the coordination challenge. A systemic concept of addressing security from a WEF nexus perspective can support a push towards operationalizing abstract notions and the development of meaningful indicators at different levels and for diverse social groups.” Biggs et al.

(2015:392) also state that one strength of the nexus is that indicators can be employed to quantify the complexities of dynamic systems.

The nexus approach lends itself to participatory (De Strasser et al., 2016; Johnson and Karlberg, 2017) and transdisciplinary (e.g. Kurian, 2017) methods of analysis and implementation. Many of the emerging methods emphasize the importance of stakeholder dialogue to tease out the nexus interlinkages in the local context, and to identify pressure points and priorities within the system in a bottom-up manner (e.g. FAO, 2014; Karlberg et al., 2015). However, application of these methods remains very limited (e.g. Halbe et al., 2015; Howarth and Monasterolo, 2016).

Several critiques of the nexus approach have emerged. The nexus framework remains dominated by economic market evaluation (e.g. resource use efficiency, and the 'security' framing in response to geopolitical realities), and does not pay enough attention to equity, environmental and social risks, and livelihoods (Allan et al., 2015; Biggs et al., 2015; Middleton et al., 2015; De Grenade et al., 2016). Allouche et al. (2015:611) caution that "the emergent framing of the nexus leads to demand-led technological and market solutions that ignore the supply-side limits and political dimensions in terms of control over and access to resources". Furthermore, Dupar and Oates (2012) warn that nexus thinking, in its simplistic form, might lead to the commodification of resources most readily or profitably monetized (perhaps for short-term gain), underplaying other long-term environmental externalities, such as biodiversity loss, pollution or climate change. They argue for a nexus approach that is sensitive to political economy issues, including open, inclusive and transparent negotiation and rights-based approaches. Meanwhile, socio-ecological systems analytical framework approaches have been critiqued as under-theorized or under-politicized, in particular regarding historical and relational considerations. Foran (2013) has argued for linking system frameworks that identify significant nodes of interaction with political ecology frameworks that provide insight into the social regimes that govern those nodes. Furthermore, the nexus components are often conceptualized as equal parts, when in reality, power imbalances between sectors (e.g. energy often having more power than water or agriculture) or different aspects of water or agriculture falling under different ministries, can lead to unequal benefits or trade-offs. Bazilian et al. (2011:7903) concluded that, "while it is useful that there is a growing acknowledgement of the need to consider the EWF nexus holistically, the tools and expertise are not fully available to support the political dialogue." Thus, the polycentricity of the WEF nexus can only succeed in practice if considerably more attention is given to issues of political economy and collaborative governance.

De Grenade et al. (2016:15-16) state that the nexus "fails to adequately acknowledge the environment as the set of natural processes underpinning the nexus." They argue that the narrow focus on a few selected resources limits the nexus research to adequately engage with multiple systems that sustain human wellbeing. The authors emphasis that "Nexus research should firmly include the environment as a fundamental conceptual framing: the environment provides the resources needed to support security and human well-being; the environment is the source of multiple drivers and stressors that stimulate the need for adaptive capacity and action; and the environment is a series of complex, dynamic, interlinked systems that are affected by, but exist independent of, human actions." Biggs et al. (2014:85) extend this critique by arguing that "livelihoods need to be better encompassed within nexus thinking to ensure environmental securities are applicable at multiple scales for enabling sustainable livelihoods, and not only sustainable development."

The emphasis on the macro-scale drivers of resource consumption patterns (global, international, transboundary) (Hoff, 2011) has led to "inconsistent, and frequently inadequate, attention to the complex variety of resource-user perspectives at local scales" (Biggs et al., 2015). Another problem with scale is that "the boundaries of different nexus dimensions are not clearly defined, and to complicate matters, it is rare that they align with established management/administrative boundaries, e.g. river basin, urban centre, or even geopolitical divisions." (Yillia, 2016:95). Furthermore, Allan et al. (2015) pointed out that "a profound and useful conceptualization of the grand nexus was lacking" and "the absence of an overarching theoretical frame was making it impossible for those engaging to communicate effectively." The wide range of studies have used sometimes ambiguous definitions and inconsistent indicators (De Strasser et al., 2016). "While useful to adapt to different understandings and circumstances, this can create confusion when it comes to comparing results across basins." Insufficient critical conceptualization of the nexus, and in particular the social science conceptualizations, led Foran (2015) to conclude that "the nexus is an immature concept" and is "under-theorized". Normative statements around reductions in inequality, and harmonization of policies and regulations, are however "not yet accompanied by a rigorous analytical framework that includes the nexus between financial investment, the developmental state, different classes of people, and distributional outcomes on the ground." And: "For example, they have not seriously asked how, under particular social regimes, farmers and workers are organized so as to produce not only resources, but also profit, power, and social change".

2.4.1.2 Strengths and weaknesses of the SLA in the context of sustainable development

Through it bottom up approach, the SLA re-focuses the assessment on sustainable development from a regional and national focus back to the sustainable livelihoods and poverty eradication focus (Biggs et al., 2015). It therefore puts the needs and interests of the most vulnerable and marginalized at the forefront. As an analytical tool, the SLA highlights factors that influence a community's ability to enhance livelihoods and eradicate poverty (Biggs et al., 2014). By combining different perspectives and disciplines, livelihood studies have led to new insights and deeper reflection. "Livelihoods analysis frameworks and methods definitely offer a way of uncovering complexity and diversity in ways that has often not been revealed before" (Scoones, 2009:185).

The frameworks developed from the sustainable livelihoods perspective have attempted to systematically link the micro- to the macro-level. While the starting point is the micro-level (i.e. the local perspective) the particularities of poor people's livelihoods are linked to wider institutional and policy processes taking place at various levels (Scoones and Wolmer, 2003; Scoones, 2009; Pardoe et al., 2018). Furthermore, Fisher et al. (2013:1105), point out that "the framework presents various entry points for thinking holistically about the contribution of ecosystem services to livelihoods" and that it is highly compatible with other frameworks because of its inherent flexibility.

Clark and Carney (2008) argue that the sustainable development framework remains weak in analysing the influence of policies and political economy and is inadequately focused on the underlying causes of poverty. This is because the focus tends to remain on the micro/ household level rather than taking a cross-scale focus. Hence, the understanding of the local context and responses is often not linked to wider national, regional and global processes. Scoones (2009), on the other hand, provides several examples where studies have focused on issues of power and politics (e.g. Davies and Hossain, 1987; Hobley and Shields, 2000) but these have remained at the margins of the debates. He argues that it is not so much the SLA that should be criticized, but the simplistic application of the framework. Too often the emphasis is placed on the five capitals, while other important components of the framework are not given adequate attention. "In particular, the focus on 'capitals' and the 'asset pentagon' kept the discussion firmly in the territory of economic analysis." (Scoones, 2009:178). The author continues to argue that many studies remained limited to quantitative analyses where in fact in-depth qualitative understandings of power, politics and institutions were needed (Scoones, 2009). Scoones (2009:181-182) elaborates on four shortcomings which have led to a decline of the SLA:

1. The lack of engagement with processes of economic globalization (e.g. big shifts in the state of global markets and politics);
2. Failure to link livelihoods and governance debates in development (mainly because of the weak theorization of power and politics);
3. The lack of rigorous attempts to deal with long-term secular change in environmental conditions (especially regarding climate change);
4. Inability to grapple with debates linked to fundamental transformatory shifts in rural economies.

In relation to the water-energy-food nexus, Biggs et al. (2015) pointed out that the SLA approach does not pay adequate attention to how the nexus dynamics impact on the different livelihood capitals. Given that the SLA has for the most part focused on poor households and communities in the rural context, the question arises whether the SLA remains applicable in a rapidly urbanizing world in which institutional processes and vulnerability contexts significantly alter people's livelihood options in complex context-specific ways. It also appears that linkages and interdependencies between the urban and rural contexts are not given enough attention in existing livelihood studies. This also links to the point made by Scoones (2009) and others that the rural household and its linkages to the rural economy (especially in relation to the agricultural sector) has seen significant changes in many parts of the world.

2.4.1.3 Compatibility of methods used to study the WEF nexus and SLA

A diverse set of methods and tools for the study of the nexus have been drawn from a wide range of fields including environmental sciences, hydrology and water resources management, social sciences, energy, agricultural sciences, biological sciences and engineering, as well as policy and governance studies. Albrecht et al. (2018), in a nexus methods review based on 245 journal articles and book chapters, reported that social science methods were used in only 26% of the publications analysed and were often used in combination with other methods drawn from the natural, economic and engineering sciences. Most nexus studies (70%) employed quantitative methods, while mixed quantitative and qualitative methods were used by only 19% of studies. Examples of the latter include Keskinen et al. (2015) who used hydrologic models together with a spatial analysis of census demographic data and participatory scenario analysis. Participatory scenario analysis was also used by Karlberg et al. (2015) in combination with WEAP-LEAP modelling, to study the impacts and trade-offs of rapid developmental trajectories pertaining to agriculture, energy and environment.

The literature review conducted for this study highlighted that the interdisciplinary and multi-sectoral nature of the nexus approach makes it well suited to participatory workshops, focus groups and stakeholder dialogues (Karlberg et al., 2015; Keskinen et al., 2015; De Strasser et al., 2016) and methods such as the Delphi technique and agent-based modelling (Smajgl et al., 2016). Such qualitative and transdisciplinary methods can help to identify and develop policies and interventions which are socially and politically relevant and implementable within the local historical and socio-political context (Foran, 2015) and can thus contribute to livelihood protection and development within nexus constraints. They also allow for the necessary flexibility and feedback opportunities. Nevertheless, they can be combined with quantitative and qualitative methods at multiple higher scales where nexus dynamics evolve, and higher-level planning decisions are made (Scott et al., 2011; Smajgl et al., 2016).

A significant hindrance to identifying compatible methods for linking SLA analysis with nexus analysis is the question of disparate scales. The historical emphasis of the nexus approach on the global or transboundary scale, together with the development of mostly quantitative methods and tools, contributes to an explanation of why there appear to be so few studies of nexus dynamics and implications for livelihoods at local level. Data at smaller spatial scales (resolution down to household or even individual level) are seldom available (Ringler et al., 2013), although innovative multi-scale methods are beginning to emerge (e.g. Mukuve and Fenner, 2015; Spiegelberg et al., 2017). Studies of nexus-livelihoods relationships need the development of robust data sets at cascading scales and specifically tailored for this purpose.

A few studies are pointing the way towards the use and integration of multiple methods when assessing the nexus from a livelihoods perspective. Household surveys were used by Spiegelberg et al. (2017) to identify elements and interlinkages of the nexus in relation to the five capitals of the SLA, within a socio-ecological network analysis. Foran (2015) compared the use of complex systems modelling methods with critical social science methods in the context of nexus research and described the challenging epistemological differences between these approaches. Nevertheless, Foran (2015) proposed that an interdisciplinary analysis based on synergies between these two approaches could be developed. This could be a very useful approach to nexus-livelihoods studies.

In sustainable livelihoods research and practice, participatory, people-centred and action research methods are often used with the aim to build adaptive capacity within different and dynamic livelihood contexts (Reed et al., 2013). While various methods and tools commonly used in livelihoods research could address some of the methodological weaknesses of nexus studies, the SLA methods also have significant limitations. For example, it has been argued that SLA methods have been too applied, i.e. focused too narrowly on immediate local contextual problems and that for the most part they have not been able to capture processes related to the political economy (see Scoones, 2015). The discussion above highlights that methods used for nexus as well as livelihoods studies fall short on investigating the effects of the political economy on nexus dynamics and livelihood resilience.

2.4.1.4 Similarities and differences between the WEF nexus approach and the SLA

Significant similarities between the nexus approach and the SLA can be observed. They demonstrate the compatibility and complementarity of the two approaches and imply that considering both jointly could indeed make meaningful contributions for the delivery of more equitable development outcomes at the household scale:

- Both approaches are based on systems thinking;
- Both take a multi-sector approach;
- Both build on inter- and transdisciplinarity;
- Both find direct application in the international policy arena;
- Both have arguably been pushed too strongly or too quickly into the policy arena and have been dominated by the policy community, leaving scientists and the empirical evidence base lagging;
- Both have a strong focus on sustainable development but use different definitions of sustainable development (e.g. nexus: efficiency and optimization as well as security; SLA: well-being and an adequate and decent quality of life for current and future generations); and
- Both emphasize the importance of participatory processes for knowledge integration and the discussion of trade-offs. But each approach focuses on role players at different scales. Nexus research is more concerned with key role players from the different sectors (higher level), whereas the SLA emphasis is on the households and communities that need to be engaged.

Fisher et al. (2013:1098) reviewed frameworks focusing on ecosystem services and poverty alleviation, highlighting that research concerned with poverty alleviation "must recognize social differentiation, and be able to distinguish between constraints of access and constraints of aggregate availability of ecosystem services." Poor people can be vulnerable to changes in aggregate supply or access to provisioning and supporting ecosystem services that contribute to livelihoods. They further elaborate that "access to provisioning services depends on the aggregate availability of these, and on entitlements." Regulating ecosystem services which are important for reducing environmental vulnerability, for example through the filtration of clean water and flood regulation, do not necessarily require direct access for people to benefit from them. For people to benefit, it is more important that the function of the specific services is maintained. This in turn often requires the involvement of a diverse set of actors over larger spatial scales (Fisher et al., 2013). So far, neither the SLA (e.g. Reed et al., 2013) nor the nexus framework have paid enough attention to the issue.

With a few exceptions (e.g. Lerner and Eakin, 2011 for the SLA, and Ramaswami et al., 2017 for the nexus) both approaches fail to conceptualize the rural-urban continuum and the profound shifts taking place through rapid urbanization and development of secondary and tertiary economic sectors. These shifts have implications for both, nexus (demand-supply shifts) and livelihoods (fewer livelihoods directly dependent on natural resources). As one can see even when discussing similarities, differences become apparent. Table 3 lists some of the more significant differences based on the literature reviewed.

Table 3 Some differences between the SLA and WEF nexus approaches.

SLA	Attribute	Nexus approach
Micro (primarily household /community) up to district level	*Scale*	Macro (larger systems, e.g. river basins, countries or regions)
Local perspective	*Starting point*	International and basin perspective
Bottom-up approach, qualitative and quantitative	*Methods*	Top-down approach, primarily quantitative analyses
SLA: explicitly normative: focus on poverty and marginality (e.g. Scoones, 2009:183)	*Relation to normativity*	Weak engagement with normativity
Equity, adequate and decent quality of life with social and environmental sustainability in mind	*Understanding / goal of sustainable development*	Resource use efficiency, optimizing resource use, trade-offs and synergies, security
Development aid community	*Influential / dominant actors*	Policy makers, private sector (risks to trade and markets, investments in large dam projects, climate change responses, etc.)

2.4.2 Empirical evidence of livelihoods and WEF nexus linkages

The interrogation of four key papers as case studies provided additional insights into the compatibility of the WEF nexus approach and the SLA, in terms of conceptual and practical linkages, methods, strengths and weaknesses of the nexus-livelihoods analysis. A summary of the findings is presented here, while a more detailed discussion of the four key papers can be found in Appendix 1.

2.4.2.1 Summary of how the four selected articles have successfully been able to provide insights into nexus-livelihoods linkages

Spiegelberg et al., 2017 (Dampalit Sub-watershed, Philippines): The methodological approach provided a detailed understanding of local nexus linkages (between upland farmers and downstream fishers) and identified that these linkages were limited. The investigation into additional linkages (e.g. relation between farmers and fishers to the local ecosystem, and relations between the two groups) helped to understand what factors shaped the use and management of the resources in the watershed. The study also provided important insights into the dependency but also impact of the livelihood activities of the two social groups on the resource base of the sub-watershed. Furthermore, the study through its cross-scale analysis was able to provide suggestions how the local nexus could be strengthened in the future as well as highlighted where potential problems could arise. Interrogation of the five livelihood capitals helped to surface the consumption and production of water, energy and food, as well as how the two groups related to the supporting ecosystem.

Foran, 2015 (Greater Mekong Sub-region): The author demonstrated that a transboundary nexus study can indeed adopt a livelihood lens. By combining complex systems thinking and critical social science methods, the study was able to start assessing the political economy, existing power constellations and dominant narratives that underpin the WEF nexus in the region. In so doing, the study addressed the weaknesses of nexus and SLA research. The assessment showed how marginalized groups continued to carry most of the cost of changes in the nexus dynamics and found very little evidence of sustainable local development outcomes. Aware of their epistemological differences, Foran strongly advocated for interdisciplinary analyses that build on the synergies of the two approaches.

Keskinen et al., 2015 (Tonle Sap Lake, Mekong River Basin): The study achieved a cross-scale analysis by embedding the investigation into the local WEF nexus in the larger transboundary WEF nexus. This was done through analyses of different spatial and temporal scales. To better understand livelihoods dynamics a trend analysis was conducted. Using three spatial scales, the study was also able to achieve a better understanding of how the linkages of rural livelihoods to the nexus might differ from those of urban livelihoods and the degree of dependency on natural resources. By adopting a strong transdisciplinary approach and engaging local government officials in the study, particularly the future scenario development, joint knowledge development was facilitated. This led to a better understanding of the connections between geographic scales, nexus dimensions and livelihoods under different water-energy-development and livelihood-development pathways.

Karlberg et al., 2015 (Lake Tana Sub-basin, Ethiopia): The research showed that a participatory scenario-based nexus analysis is a useful tool with which to gain a system-wide understanding of the implications of divergent sectorally driven policy approaches on socio-economic development. An iterative process was followed with stakeholders to fine-tune the toolkit (quantitative) analysis, thus providing local validation of possible outcomes and relevant interpretation within the livelihood context. This approach can assist in identifying balanced development outcomes across the nexus which give optimal support to existing local livelihoods and livelihoods development opportunities, while also delivering on national energy and food security goals.

2.4.2.2 Discussion of the results of the empirical evidence

Where are the intersections between WEF nexus and livelihoods and how do they impact on one another?

Spiegelberg et al. (2017) highlighted that the intersections between the WEF nexus and livelihoods are highly complex and that to understand these one needs to first understand in greater detail the local nexus linkages and how these in turn are affecting specific livelihoods activities. Focusing on the regional transboundary scale, Foran (2015) illustrated the need to incorporate the larger political economy in the assessment to understand how and why the nexus intersects with livelihoods. Without paying attention to existing power constellations, studies will continue to fail to show the trade-offs, cost and benefits of large development plans in relation to the provision of water, energy and food and the maintenance of ecosystems that support the provision. In the case of the Tonle Sap Lake, Keskinen et al. (2015) showed that the intersections between the local WEF nexus and local livelihoods are very direct. Large scale upstream interventions (such as the construction of a hydropower dam) have direct consequences for local livelihoods, especially farmers and fishermen. Nevertheless, scenario-driven research can demonstrate that alternative policy options are possible which can lead to balanced outcomes, i.e. meeting the goals for energy, food security and environment, while reducing negative impacts on resource-dependent livelihoods, and even providing further livelihood opportunities (Karlberg et al., 2015).

What are the benefits of a livelihoods focus for nexus study?

Spiegelberg et al. (2017) structured a socio-ecological network analysis around the five livelihoods capitals and were able to gain a much clearer understanding of how the two social (livelihood) groups relate to the watershed, and how they utilize water, energy and food (production and consumption) for their livelihood activities. Such an approach enables the identification of potential user conflicts, and where future trade-offs or insecurities might arise (e.g. the importance of and high dependency on groundwater in the area). Furthermore, the results from the household surveys showed that different livelihoods have differential impacts on the sustainability of the nexus. While Foran (2015) did not formally include a livelihoods analysis, the study shows how changes in the nexus constellation through the development of hydropower dams have negative impacts on the fishing and farming livelihoods in downstream countries. While one can expect differential impacts across the countries in the region, the development of the dams would increase rural livelihood insecurities in some basin areas, which in turn would have negative consequences for food security and accelerate urbanization trends.

Paying attention to livelihoods dynamics, Keskinen et al. (2015) were able to show that, while agriculture and fishing remained the most important livelihood activities in the study area, people were shifting away from natural resource-based activities and that such shifts have significant implication for existing local nexus dynamics. However, the authors also highlight that urbanization and livelihood diversification trends do not necessarily relieve the pressure of resource-based sectors on the resource base since absolute numbers of participants in agriculture and fishing continue to increase. The analysis by Karlberg et al. (2015) illustrated how a failure to identify and acknowledge the potential impacts on livelihoods under sectoral development policies can lead to unintended negative consequences and local coping responses by those affected, which can place additional pressure on already over-utilized natural resources.

What are the benefits of nexus lens for livelihoods analysis?

The nexus lens enabled Spielberg et al. (2017) to bring to the fore cross-sectoral and cross-scale linkages that are of importance to the sustainability of the livelihoods of the fishermen and the farmers. The integrative systems approach showed how activities in the sub-watershed affect the overall sustainability and resource security in the sub-watershed. Similarly, the cross-scale analysis applied by Keskinen et al. (2015) enabled a better understanding to what extent local communities depend on water, energy and food resources, and how planned infrastructure investments could potentially reduce the resilience of livelihoods linked to agriculture and fishing. While Karlberg et al. (2015) did not undertake a livelihoods analysis, they were able to show the strong dependency of local livelihoods on the natural resource base, and the urgent need to foster alternative livelihood options and a more diversified livelihood system so that the depletion of the natural resource base can be reduced.

What can a combined WEF nexus – livelihoods approach tell us about risks and vulnerabilities of communities and impacts on achieving the SDGs?

In terms of risks, Spiegelberg et al. (2017) highlighted the high dependency by local people on groundwater. It also appeared that tenure security remained a critical determinant of vulnerability. The study clearly showed that understanding the interlinkages of the WEF nexus (whether local or regional) is necessary but not enough to identify trade-offs and synergies. The larger political and economic processes need to be accounted for as they directly influence which livelihoods strategies people pursue and the allocation of the WEF nexus components themselves. The linked analysis identified several new livelihood and sustainability opportunities such as development of the agricultural and fisheries waste economy, which could contribute to increased resilience and achieving the SDGs.

Foran (2015) showed that a combined approach is critical in understanding the real costs and benefits of large-scale development initiatives (such as the development of large dams) and how they translate into successful or failed local development outcomes. The combined approach used by Keskinen et al. (2015) allowed them to highlight how future hydropower development plans could lead to increased local and national food insecurity and vulnerability of livelihoods depending on the lake. Furthermore, they were able to gain an understanding of the implications of the four alternative scenarios for the resilience of existing livelihoods opportunities. Where existing vulnerabilities are already very high, as for example in the Lake Tana area (Karlberg et al., 2015), any significant change to the resource base on which most of the population depend would escalate vulnerability. Alternative options would be severely constrained, and the population would be forced to scale up activities, which are not sustainable.

So, in general, achieving the SDGs becomes more probable when combining the views of the WEF nexus into the livelihoods and vice versa.

2.5 Discussion and conclusion

The aim of this study was to gain a better understanding of how the nexus approach can assist in building livelihood resilience, and what is needed to strengthen our understanding of, and empirical evidence for how the WEF nexus intersects with local livelihoods. The assessment of the two approaches showed that the WEF nexus and SLA are fundamentally compatible and when utilized jointly can make important contributions in understanding the intersection between the nexus and the resilience of local livelihoods (as highlighted also by Mabhaudhi et al., 2019 and Nhamo et al., 2019). However, our analysis also showed that just applying the two approaches together may not lead to greater insights. Similar weaknesses could be identified in the individual and additive approaches. In their current application, both approaches fail to account in meaningful ways for the political economy and power constellations within and across specific decision-making levels. As a result, they then also fail to acknowledge scales of impact and response. Both require a more systematic engagement with transdisciplinarity in terms of the use and integration of multiple methods from social science and systems modelling which are supported and validated by quantitative as well as qualitative data sources. Another important gap that requires attention is the need to interrogate the relationship that local communities have to their local ecosystems in times of rapid urbanisation and changing livelihood trends.

Thus, our exploratory review indicated that there is merit in taking a combined approach but that there are remaining conceptual and methodological difficulties to overcome. The four selected key papers provided useful insights into how a combined approach could be further developed. Some of these studies also suggest that alternative livelihood research methods (other than SLA) should also be explored in future research.

This review was not based on a comprehensive literature analysis; indeed, despite the large body of nexus literature published, there has been remarkably little true focus on the household and community level before the completion of this phase of the project. Some of the research at this scale also fails to incorporate socio-ecological considerations beyond the ‘WEF footprinting’ (simple resource flows analysis) approach. Nevertheless, other relevant research may have been omitted at this stage, and so the review should be viewed in this light.

In conclusion, a cross-sectoral nexus-based analysis can provide guidance to policy makers and planners on integrated planning for optimised socio-economic outcomes. This could mean ensuring developmental trajectories to be more sustainable, resilient and productive / successful towards the intention of the initiator – which based on our South African perspective, is mostly the state or the greater donor community. Finally, we also assume that with the deeper and more relational focused interrogation of the nexus and livelihoods other positive spin-offs could be achieved. With that the SDGs may not be so out of reach as especially feared in the developing world.

CHAPTER 3: METHODS AND MATERIALS

To gain a meaningful understanding of how the WEF nexus plays out 'on the ground' and mediates livelihoods at the local scale, we applied a mixed method research design. The following methods were developed to allow for comparisons across sites and to enable a qualitative and quantitative assessment of the nexus:

- A set of indicators from the South African National Census 2011 (Statistics South Africa, 2011a)
- A household questionnaire focusing on the access and use of the three resources
- Household WEF resource audits
- Focus group discussions at the community scale (focusing on sensitive questions and/or decision-making processes)
- Mapping WEF resource supply systems at community level
- Additional methods including photovoice and expert interviews

The intention was to first develop a quantitative understanding of how water, energy and food are utilized at household level (questionnaire and audit), where shortfalls can be identified, and how these lead to trade-offs that households are forced to make. The quantitative understanding was then substantiated with the qualitative investigation (focus groups, resource mapping, expert interviews) into the reasons behind resource insecurities and trade-offs. To identify and capture important cross-scale linkages, these methods were applied at different scales, with some focusing on the household level and others on the community level, and in some instances extending to the municipal and catchment level.

Another important aspect of the research design was the invitation extended to unemployed youth from the research sites to become co-creators of knowledge and assist in the sense-making of specific nexus processes and challenges experienced in their respective communities. Each Masters student worked with a team of youth trainees from the selected communities, guided by the youth co-ordinator. The youth were trained as CRAs with the intention to generate rich data on sensitive issues, stimulate nexus thinking, and increase employability.

3.1 Case studies in three catchment areas of South Africa

Using different types of poor households as the entry point, we examined the ways in which the WEF nexus affects livelihoods across three catchment areas, namely, the Berg (Western Cape), uMngeni (KwaZulu-Natal) and Keiskamma (Eastern Cape). These catchments are of major socio-economic importance and are already experiencing extraordinary development pressures and resource competition. They are also home to several communities across the rural-urban continuum.

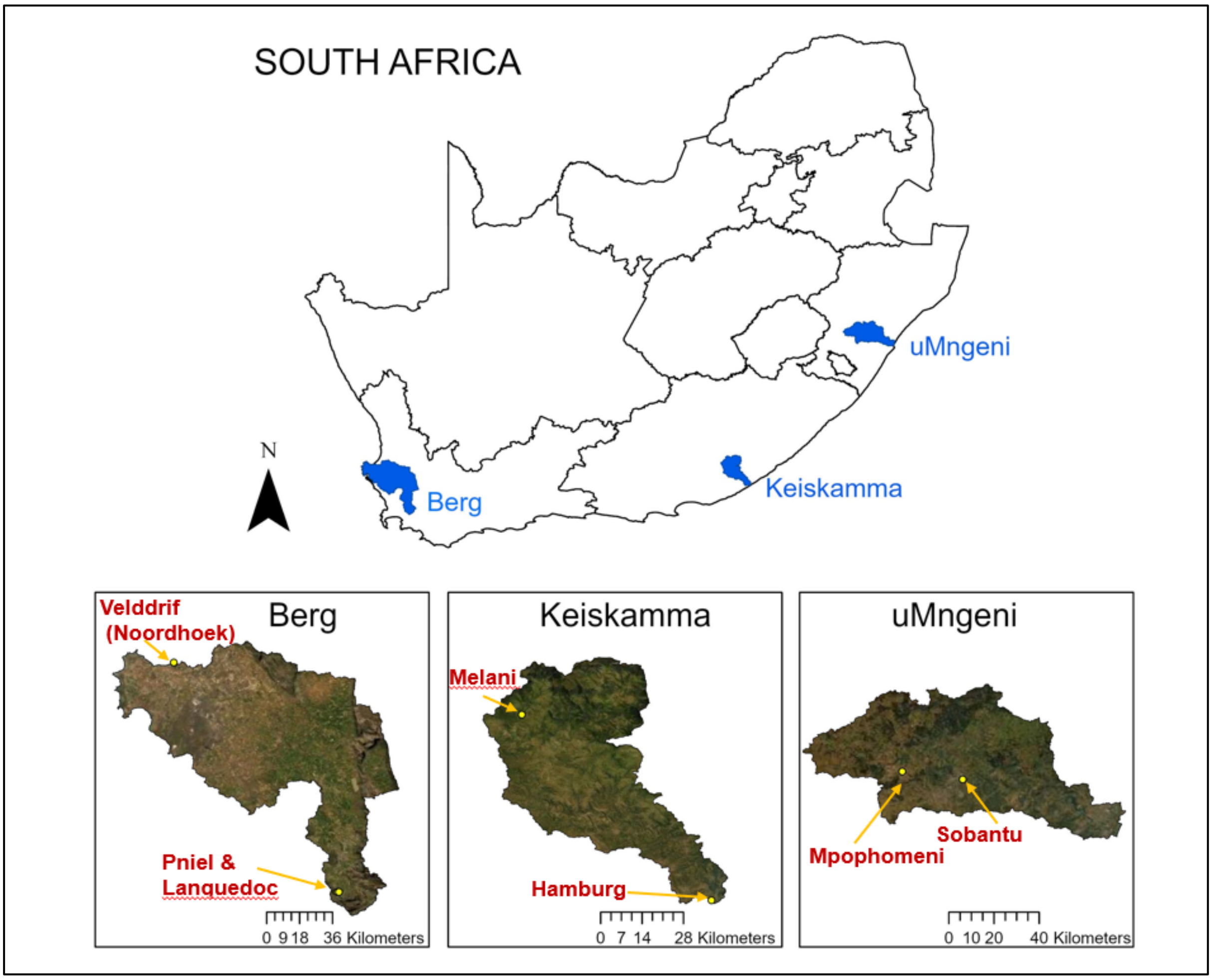


Figure 2 Maps of the three catchments and the seven study sites. The sites are captured as yellow dots.

3.1.1 Overview of the Berg catchment

The Berg River catchment (Fig. 2), located in the Western Cape Province, represents an excellent example of an economically important regional system under high resource extractive pressure. This pressure is located at the nexus of water quantity and quality, food production and energy supply, within the wider context of a rich biodiversity, intensive land use and a projected dryer future and more extreme events such as drought due to climate change (Midgley et al., 2014; Cullis et al., 2019). Due to its position in a Mediterranean-type climate region, rainfall is concentrated during the cool winter months, with a steep gradient from the south-eastern upper catchment (>1200 mm per year) to less than 300 mm per year at the north-western estuary. The catchment is an integral part of the Western Cape Water Supply system (WCWSS). Of the 5 major dams that contribute water to the WCWSS, one is in the neighbouring Breede River catchment (Theewaterskloof Dam). Water is transferred from this dam via an inter-basin transfer scheme to the Berg catchment and the WCWSS. The WCWSS supplies the City of Cape Town (CCT) and augments the local supply schemes of the towns of Paarl, Wellington, Stellenbosch, Saron and the West Coast District Municipality. The system also supplies water to irrigators along the Berg and Eerste Rivers. Bulk water supply infrastructure is mostly owned and operated by the CCT (for example Steenbras and Wemmershoek Dams). The National Department of Water and Sanitation (DWS) owns and operates some of the infrastructure (such as Voëlvlei Dam) within the WCWSS, whilst some local authorities own and operate local supply schemes themselves (for example the West Coast District Municipality and Drakenstein Local Municipality). The majority of towns in the Berg Water Management Area are either wholly or partially supplied with water from this integrated scheme. The main land uses in the catchment fall primarily into agricultural (60% of the area, of which 53% is irrigated), natural (36%), urban (2.5%) forestry (1%) (DWAF, 2004a; Cullis et al., 2019).

Pollution in the Berg River caused by agro-chemical runoff from intensive farming operations and ageing and under-capacity waste water treatment facilities is a cause of great concern to communities, farmers and industries in the West Coast and Cape Winelands District Municipalities (DWAF, 2004a; Cullis et al., 2019). In addition, there is increasing concern that the water will not be adequate in future to service the entire region. Cullis et al. (2019) highlight that, while the catchment has historically been largely rural, it has seen an increase in population throughout the catchment (1996-2011) and an associated substantial increase in dwelling structures and land use change, particularly in the middle-upper catchment.

It has become clear that the planned industrial development at Saldanha Bay near the Berg estuary will be constrained by water availability unless the management of the resource is changed significantly. This is complicated by the high demand on Berg River water resources by the CCT, which is located outside the catchment, and by intensive agricultural production and dependent secondary agro-industries (Midgley et al., 2014). Water must also be allocated to the ecological reserve which provides critically important ecosystem services. Furthermore, water security is also threatened due to the extent to which alien invasive vegetation has infested the region.

The region imports almost all its electricity requirements from the national grid through the utility ESKOM (DEA&DP, 2013). This energy is heavily coal-based, with a small nuclear component. The enormous reliance on fossil fuel renders the region vulnerable to disruptions in complex supply lines (DEA&DP, 2018). The electricity supply has been strained for several years due to inadequate investments and maintenance and this has impacted on all users (DEA&DP, 2018). The expansion of windfarms and solar power remains limited in the region despite the provincial government moving towards a green economy, due to the region not being included in the Renewable Energy Development Zones (REDZ) that have been identified to promote renewable energy in the country.

Roughly sixty percent of the Berg River catchment area is agricultural, dominated by grapes and deciduous fruits (mostly irrigated), small grains (e.g. wheat, canola) and livestock (dairy and beef cattle, sheep) in the drylands of the lower catchment. Significant foreign revenue earnings flow from the export of fruits and wine/spirits, with most of the production being exported. The fishing sector is of great significance along the West Coast. Agriculture/fisheries also drives much of the secondary economy in the form of fruit, vegetable and fish processing.

Despite the strong performance of agriculture and fisheries, and sufficient food availability through local production and trade, there are pockets of poverty in urban and rural areas across the catchment that often manifest as various degrees of household food insecurity. Social grants are critical as enablers of food purchasing in unemployment/poverty 'hotspots'. Many households are vulnerable to food inflation and price spikes. Malnutrition and stunting in children are also more prevalent in indigent households (Sartorius et al., 2020).

The Berg catchment is experiencing rapid population growth and urbanisation, and an increasingly young population requiring care/schooling or looking for employment. High-density settlements are growing where there are more job opportunities. Some of these are changing the face of older, well-established settlements. Some of the older settlements (e.g. Pniel) are facing the threat of 'gentrification' which gradually renders land and housing less affordable to the original inhabitants.

Overall, unemployment rates (around 10% in 2018, WCG: Provincial Treasury, 2019) are not as high as the national or provincial averages, although the youth everywhere are particularly disadvantaged. In the West Coast District Municipality (including Velddrif on the Berg River estuary), employment in the sector agriculture, forestry and fisheries contributed 38.5% of all employment in 2018 (WCG: Provincial Treasury, 2019), followed by wholesale & retail trade/ catering & accommodation (16.7%). In the upper and mid-Berg regions of the Cape Winelands District Municipality (including the Banghoek Valley with the communities of Pniel and Lanquedoc), these figures are 21.7% and 22%, respectively. Other strong employment sectors in the Cape Winelands District Municipality are finance/insurance/real estate/business services, and community/social/ personal services (WCG: Provincial Treasury, 2019).

According to the Census 2011 (Statistics South Africa, 2011a), certain Wards representing recently established informal settlements with mostly first-generation migrants show unemployment rates of up to 60%, and most households with a monthly income less than R3200. Thus, chronic poverty and associated food insecurity are prevalent in such 'hotspots'. Municipalities struggle to deal with the backlog for housing and basic services in the face of continuing in-migration, combined with constrained budgets. In many Municipalities, existing bulk water and waste infrastructure has not been able to cope with these growth rates, and increased capacity is only now gradually coming online as budgets make provision for upgrades and new infrastructure.

3.1.2 Overview of the Keiskamma catchment

The Keiskamma catchment and the headwaters of the Keiskamma River are situated in the Eastern Cape Province (Fig. 2) in the greater Amatola region (Mhangara et al., 2011). The Keiskamma River flows eastwards for 263km and drains into the Indian Ocean at Hamburg resort (Grothmann et al., 2017). Its main tributary is the Tyume River that flows through the Melani in-land community. The catchment includes three main topographic regions, namely, the upper escarpment zone, the coastal plateau and coastal zone. The catchment constitutes an altitude range of 600 to 900m above sea level. It presents a particularly interesting comparative case study of two communities, that is, Melani-inland community located in the upper escarpment zone and Hamburg coastal community, on how water-food nexus interplay.

According to Tanga (1992), the catchment receives about 1 600 mm of annual rainfall, thus providing a conducive environment for agricultural activities. The land is largely communally owned and primarily utilised for dryland cropping, livestock farming and irrigated agriculture (van Tol et al., 2016). The catchment supplies irrigation water to three irrigation schemes: Keiskammahoek (854 ha), Tyume (231 ha) and Zanyokhwe (471 ha) (DWAF, 2004b). The catchment is also characterised by a warm coastal belt that enables a diverse horticultural production, including citrus and other fruits and vegetables (Zamxaka, 2015).

The quality of the communal lands in this catchment has deteriorated and there is a prevalence of overgrazed and eroded land (Palmer and Bennett, 2013; Ndou, 2013; Grothmann et al., 2017; Finca et al., 2019). This is partially due to the collapse of livestock and rangeland management structures that were employed through the betterment planning system of the apartheid government (Finca et al., 2019). Land cover change and degradation has also progressed due to lack of agricultural activities (Grothmann et al., 2017).

The Keiskamma River is the main source of water on which the adjacent settlements (Alice, Melani, Dimabaza, Keiskammahoek, Hamburg, and Hogsback), rely for a variety of purposes, such as drinking, livestock watering, fishing and recreational purposes (Fatoki et al., 2003). Low percentages of households have access to piped water inside their dwelling (6.1%) (Statistics South Africa, 2013). Despite this, the domestic water supply for Keiskamma communities lack proper sanitation and is continually polluted (Grecksch, 2015). This is due to inadequate water-borne sanitation in the Eastern Cape, one of the poorest provinces in South Africa. Problems experienced in the Transitional Local Council (TLC) with sewage discharges into the Keiskamma River escalated when RDP-housing units were connected to the Keiskammahoek Sewage Treatment Plant (KSTP) in 1997 without any expansion/upgrading of the reticulation system. Bypassing due to overflows has occurred regularly since then. According to Grecksch (2015), the treatment works were built as an anaerobic/aerobic pond system, which means that the treatment occurs naturally without added chemicals. The problem of high inflow load and poor sewage purification results in pollution of the receiving Keiskamma River (Grecksch, 2015). Fatoki et al. (2003) recommend that the Keiskammahoek Sewage Treatment Plant needs further upgrading to improve its treatment performance to ensure sustainable use of the water for the downstream users. Also, the surrounding communities are facing water insecurities related to changes in rainfall distribution and drought incidence that have impacted stream flows, water quality and salt intrusion (Africa, 2012; Grecksch, 2015).

Further issues within the catchment include a high rate of unemployment (52.8%). A majority (70%) of households in the catchment solely depend on social grants with a limited number earning income from employment (Africa, 2012). There is little opportunity for income-generating activities. Several scholars have found the area to be food insecure, as households are income unstable and uncertain, high levels of unemployment with declining household activities like food gardening (Africa, 2012; Ndhleve et al., 2013; Dodd and Nyabyudzi, 2014; Martens, 2015). A large majority of the households are in one way or another directly or indirectly dependent on agriculture (farming), and marine and estuarine fishing (Africa, 2012). The decreasing trend of freshwater availability, estuarine ecosystem services and land availability that provide natural goods and services is of great concern.

The communities around the catchment area are connected to electricity. However, they still depend on energy sources such as wood, cow dung, and paraffin (Lloyd, 2014). People rely on firewood for fuel and the intensive harvesting of wood has resulted in the invasion of unpalatable patch dwarf shrubs and the promotion of soil erosion. Mamphweli and Meyer (2009) recommend the provision of low-cost electricity for small businesses including the growing of crops, raising of chicken broilers, manufacturing of windows and doorframes, sewing, baking, etc.

3.1.3 Overview of the uMngeni catchment

The uMngeni catchment covers an area of 4 400 km^2 (Fig. 2). It is an important watershed supplying most of its water to the cities of Pietermaritzburg and Durban within the province of KwaZulu-Natal (KZN). The catchment supplies water resources to approximately 45% of the KZN population, further, it is a region that produces approximately 11% of the country's gross national product (Hay, 2017). To ensure water supply, the catchment is impounded with four dams, namely, Albert Falls, Henley, Midmar and Inanda Dam, which are owned by the DWS (state owned). However, Umgeni Water as the main water board in the catchment has been commissioned to manage these dams on behalf of the state. These dams maximize the water storage capacity of the system; however, all dams are eutrophic due to the growing population, lacking proper sanitation, resulting in high loads of nutrients, faecal bacteria and suspended solids, which in return compromises water resources quality. Due to an increase in population, urban sprawl and other land based activities about 50% of the upper catchment has been transformed, meaning pressure on all natural resources (Hay, 2017); population increase and especially urban sprawl result in an increasing demand for services, i.e. water, energy and food. Thus, the catchment is vulnerable to waste, water quality issues which ultimately threatens water availability and security, further, impacting on sustainable socio-economic growth and development. The catchment is complex due to the mixed land uses and its hydrology (Warburton et al., 2012; Schulze et al., 2004). The upper parts of the catchment (source to Midmar Dam) are dominated by commercial forest plantations due to the high annual rainfall, exceeding 700 mm (Warburton et al., 2012). Large scale commercial agriculture (cattle, diary, piggeries, poultry and forestry) and conservation areas complement this as main land uses (Jewitt et al., 2020). The middle catchment (Midmar Dam to Nagel Dam) includes industrial areas and again increasing population and urban sprawl. Solid waste in the landscape and industrial waste in the water bodies is becoming an increasing challenge here. The catchment also has commercial sugar cane plantations and urban areas which is the dominant land use (van Deventer, 2012). The lower catchment is dominated by urban spaces and severe densification beyond urban boarders (Jewitt et al., 2020). Alien invasive plants are an increasing problem on terrestrial land and in aquatic bodies across the catchment (Hay, 2017).

One could assume that due to higher rainfall and several big dams, the communities are water secure. Same could be assumed in relation to food as commercial agriculture offers a significant variety of food products within the catchment. But far from true, water demand is outstripping supply (see Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas 2017) and food insecurities are rife especially in the more rural areas despite several programmes. Although an increase in food diversity and access to food can be noted (D'Haese et al., 2013). Electricity is supplied mainly by ESKOM, i.e. through coal, while other energy supplies relate to gas and crude oil, all sourced outside the catchment (Department of Energy, 2018). Hydropower and biogas are produced in limited capacities.

Looking at all three catchments it is important to note that each one is characterized by context specific WEF nexus pressures. These are outlined in Table 4.

Table 4 Key WEF nexus and livelihoods pressures in the three catchments.

BERG CATCHMENT	KEISKAMMA CATCHMENT	UMNGENI CATCHMENT
High resource extractive pressure at the nexus of **water quantity and quality**, **food production** and **energy supply** - **Rapid land use change** threatening **rich biodiversity** - High water **and land use competition** between urban and rural demands (CCT, Saldanha Bay Industrial Development Zone, intensive agriculture) - Pockets of **urban and rural poverty** **-Alien Invasive Vegetation** as a threat to water security	- One of the **poorest, highly populated** and most **neglected** rural and peri-urban areas in SA - **Health risk** (tapeworm and water pollution) - **Food insecurity** at the household level, declining agricultural activities due to water scarcity and climate variability - **Inadequate energy supply** to rural communities who mostly rely on fossil fuels **- Water scarcity due to climate variability** **- Overharvesting** of marine resources - Overgrazing resulting in degradation of land - **Declining** rural livelihoods opportunities and aspirations due to lack of skills	- **Mix of land uses**, including urban settlements, rural areas, subsistence and commercial farming incl. forestry, some industry and sand mining - Various **degraded areas** impacting on water quality and quantity - **Future water demands** cannot be met currently - Many **rural** poverty-stricken **communities** with **food insecurity** and lack of access to resources - A variety of urban informal settlements and townships within which **service delivery and health** (relating to water and food) issues are problematic - **Poor water quality**: industrial effluents; under-designed and non-maintained infrastructure

3.1.4 Local case studies

Within each catchment, two (Keiskamma, uMngeni) or three (Berg) sites were identified as local case studies (Fig. 1). The local case studies focus on representative 'resource-constrained' communities within the catchments. The settlements span the rural to urban continuum. Noordhoek is a more rural settlement on the fringes of the small coastal town of Velddrif located on the Berg River estuary. Pniel and Lanquedoc are two adjacent rural settlements with peri-urban characteristic in the mountainous regions of the Upper Berg catchment. Melani and Hamburg are rural villages in the upper and lower Keiskamma catchment respectively, with Melani being under traditional leadership. Mpophomeni is located near the town of Howick in the Midlands and is mostly under formal government but with parts under traditional leadership. This peri-urban township is in the upper part of the uMngeni catchment, while Sobantu is an urban township within the City of Pietermaritzburg and is often referred to as the start of the middle part of the uMngeni catchment.

The decision to focus on communities across the rural-urban continuum is based on the assumptions that rural communities are differently affected by nexus trade-offs than urban communities due to differentiation with regard to economic activity, service functioning, population size and density as well as connectivity (digital but also markets). For example, it is often assumed that the livelihoods of rural communities are more directly dependent on the primary economic sectors including agriculture and fisheries. Urban communities are, on the other hand, generally more dependent on the secondary and tertiary sectors and more indirectly impacted by resource constraints. Hence, the communities under investigation may have a differential relationship to the local ecosystems and ecosystem services which may partially contribute to their water and food provisioning and some aspects of energy (e.g. firewood).

To ensure that the local case studies are representative of 'resource-constrained' South African communities, the selection process was guided by the following selection criteria:

- Poor communities in urban, peri-urban, rural areas;
- Availability of census data to better describe/ differentiate levels of poverty;
- Allow for lower – upper catchment comparison/linkages;
- Resource scarcity, especially water and land, already impacting communities;
- Rooted communities with a long history;
- Existing working relationship / previous research in the communities.

3.1.4.1 Case Study sites Berg catchment: Pniel, Lanquedoc and Velddrif (Noordhoek)

Pniel and Lanquedoc[1] are adjacent settlements on the banks of the Dwars River which is a tributary to the Berg River. Both settlements operate within the jurisdiction of the Stellenbosch Local Municipality. Lanquedoc and Pniel are considered rural as they are located outside of the urban edge according to the Spatial Development Framework of 2017-2022 of the

[1] This section is a contribution of Vumande Mjanyelwa and forms part of her Masters thesis.

Stellenbosch Local Municipality. The local economy is mainly driven by agriculture with the sector contributing 22.7% of the total employment in the Stellenbosch Local Municipality (WCG: Provincial Treasury, 2018). The wholesale and retail trade / catering and accommodation sector (21.2%), finance/insurance/real estate/business service sector (14.5%). and the community/social/ personal services sector (14.4%) contribute most to livelihoods and income in the area (WCG: Provincial Treasury, 2018).

While located in close proximity, these two settlements are characterised by significantly different dwelling structures. Although Lanquedoc has an estimated area of less than a kilometre square, it has more residents than Pniel which is spatially much larger. The settlement has a prevalence of backyard dwellers and RDP-type dwelling structures. Pniel, on the other hand, has contemporary brick houses. Both settlements receive their drinking water and sanitation services from the municipality. There are several springs located in and around Pniel that residents use for household purposes such as the washing of cars. There is a municipal reserve reservoir that is used by Pniel in the event of water cuts and other unforeseen events affecting the water supply. This is unfortunately not available to the inhabitants of Lanquedoc. Most of the residents in both settlements have access to, and use electricity for lighting.

The percentage of the population that obtained a grade 12 education is significantly higher in Pniel than in Lanquedoc. Over a quarter of the population in Lanquedoc is below the age of 14, and a further 4.1% are past retirement age. In Pniel, nearly a fifth are below the age of 14 and 9% are considered elderly (65 years and older). The elderly and some parents of young children are eligible to benefit from old age and child grants provided by the state. A study conducted by the Bureau for Economic Research at Stellenbosch University for the Stellenbosch Local Municipality's Integrated Development Planning tool (2018-2022) used the c-index (community index) and identified that the two wards, part of which these two sites are located in, have a high sense of belonging and cohesion.

Velddrif[2] is a small urban settlement on the northern bank of the Berg River estuary. It is comprised of three parts, namely Port Owen – an upmarket marina, Laaiplek – the fishing harbour, light industrial, commercial and some residential, and Noordhoek – a residential area separate to the rest of the town (remnant of apartheid era spatial planning) and furthest removed from the river. This research has been concentrated within Noordhoek which is described in the 2017-2022 Integrated Development Plan as "…one of the poorest areas in the Bergrivier Municipal area". According to the Census 2011 data, Noordhoek has a population of 7135 which is distributed across age groupings as 27% being children, 68% a working age, and 4.2% elderly. The area is made up of 88% formal housing, with informal structures being mostly backyarders. Households experience relatively high levels of basic service delivery with 86% having access to flushed toilets connected to the sewerage system, 96% using electricity for lighting.

[2] This section is a contribution of Penny Price and forms part of her Masters thesis.

Situated 2 km upstream from the permanently open and navigable mouth of the Berg River, Velddrif is traditionally a fishing town with a harbour and a fish processing factory. Fisheries have played a pivotal role in the development and economic activity of the town as reflected in the key sectoral contributions to the Bergrivier Local Municipality Regional Gross Domestic Product (Bergrivier Local Municipality, 2017). Agriculture, forestry and fishing is the biggest contributor at 28.8%, followed by manufacturing at 22.7% and then by wholesale and retail trade, catering and accommodation at 12.9% (WCG: Provincial Treasury, 2019).

The situation of Velddrif, and Noordhoek in particular, exposes it to prevailing winds associated with this coastal area, resulting in wind-blown sand. This, along with the arid climate, is not conducive to agriculture and food gardening in the immediate vicinity (Bergrivier Local Municipality, 2014). The location on the picturesque estuary however and the town's proximity to the Cape Town metro, make it an increasingly favourable destination for tourism. The development of the nearby Saldanha Industrial Development Zone is also resulting in increasing housing demand and residential development applications in the area.

3.1.4.2 Case Study sites Keiskamma catchment: Melani and Hamburg[3]

Hamburg is a small coastal settlement near the Keiskamma estuary comprising communal, private and state-owned land. The Ngqushwa Local Municipality serves Hamburg, Peddie and Bhira, being one of the six local municipalities under the Amathole District Municipality. Hamburg is made up of 1348 permanent residents and 454 households (Statistics South Africa, 2011b). The population of Hamburg is distributed as 28.5% young children, 62.4% of working age and 9.1% elderly with an average household size of 2.9 (Statistics South Africa, 2011a). Although around three-quarters of Hamburg dwellings are formal, a very low percentage have flush toilets connected to a sewage system, or piped water inside the dwelling. However, most households are connected to electricity. Illiteracy is a challenge as very few people have received secondary education or higher.

A study conducted by EcoAfrica (2011) identified the Hamburg economy as being mainly based on cattle herding and small-scale agriculture. There is, however, a culture of males emigrating to nearby urban areas seeking employment (Martens, 2015). Women are often seen harvesting mussels on the rocky shore and local fishermen are a common sight (Africa, 2012). Apart from the artisanal use of marine resources, there is also a commercial oyster farm which is funded by the government (Martens, 2015). There is also a large influx of tourists into Hamburg during the long school holidays who are attracted by the fishing (Du Bois, 2012). These visitors stay in privately owned holiday homes, in some of the few guest houses, or in the single caravan park on the shore of the estuary (EcoAfrica, 2011). Tourists and locals alike often travel outside of Hamburg to purchase goods where prices are cheaper (Du Bois, 2012). The result is a very poorly developed retail sector in Hamburg consisting of only a few shops

[3] This section is a contribution of Thulani Ningi and forms part of his Masters thesis.

and hence very little local economic growth as much of the money that does come into Hamburg very quickly leaks out (Du Bois, 2012).

The Hamburg community depends mostly on natural resources, mostly along the seashore, but these resources are slowly declining (Africa, 2012). The residents are struggling with poverty as the majority of households in the area solely depend on social grants provided by the government, with a few depending on family member income (Du Bois, 2012). Food insecurity is a significant problem as the gathering of food from the aquatic system is unreliable (Hebinck and Shackleton, 2010). Income is unstable, with agricultural activities slowly declining (Africa, 2012).

Melani is a village located approximately 12 km north of Alice town, in the Raymond Mhlaba Local Municipality in the Eastern Cape Province, South Africa. The village has a population of approximately 500 households, housing about 3000 residents (Nkonkobe Municipality, 2012). A large majority of households in Melani have very low income, limiting their buying power. The population of Melani is distributed as follows: 26.9% young children, 61.6% of working age, and 11.5% elderly. The average household size is 2.8 (Statistics South Africa, 2011a). Melani is has mostly formal dwellings, but a very low proportion have inside flush toilets connected to a sewage system, or piped water inside the dwelling, although almost all households are connected to electricity. There is also a significant level of illiteracy as very few people have received secondary education or higher.

Food insecurity and unemployment is a big issue in Melani. The land is communally owned, and allocation is informal. Further, there is no official tenure recognition, which therefore causes a great sense of insecurity and confusion for the villagers. This has also contributed to underdevelopment of the area (Manona, 1998). The community members have limited employment opportunities due to lack of skills and a limited local economy.

3.1.4.3 Case Study sites uMngeni catchment: Sobantu and Mpophomeni[4]

The Sobantu community is a black township situated within the boundaries of the city of Pietermaritzburg. It is located within the Bayne's Spruit River valley confined by the Bayne's Spruit River to the north and expanding to the south of the Umsunduzi River (Boqo, 2001; Terry, 2008). The community is situated downstream of an industrial area which comprises of the Willowton industrial area. According to Terry (2008) the Sobantu community was established in the 1920s as a black township based on the Natives (Urban Areas) Act of 1923. When compared to other black townships in KwaZulu-Natal, the Sobantu community was seen as relatively well developed and the level of service delivery was fairly good (Terry, 2008).

Sobantu is a highly dense residential area, with both formal and informal settlements built on floodplains, which, according to Govender (2016), have a high agricultural potential. Further, this community is located in the lower reaches of the Bayne's Spruit tributary, which is ranked in the top six of the most polluted rivers in South Africa (Zuma, 2017). The community is

[4] This section is a contribution of Ntombiyenkosi P. Nxumalo and forms part of her Masters thesis.

known to have been in contact with the river in the past, using the river for fishing and garden (crops) irrigation. However, due to poor water quality and hence, threats to the health of the community, the quality of the river is no longer satisfactory for such uses (Gemmell and Schmidt, 2012; Govender, 2016).

The Sobantu community has a population of 7446 residing in 1947 households. The population comprises of 24.3% of young children, 70.4% of the working age group and 5.3% of elderly citizens (Statistics South Africa, 2011a). Though the percentage of the working age group seems high, the community has high levels of unemployment. The community is served by the Umsunduzi Local Municipality under the uMgungundlovu District Municipality with almost every household connected to electricity and having tap water in the yard. However, the affordability of these resources remains an issue in this community.

The Mpophomeni community is a black dominated township, located 12 kilometres from Howick and 120 kilometres west of Durban in the so-called Midlands of the province (Baiyegunhi, and Makwangudze, 2013; Chili, 2015). The community is split between municipal areas and areas under traditional leadership, with most of the municipal area having formal RDP houses. Further, this community is situated upstream of Midmar Dam, with three tributaries, the uMthinzima, uMhlangeni and Inguga streams, that flow through the township into the dam. According to Baiyegunhi and Makwangudze (2013), the community was established in 1972 by the South African government to move and relocate black people from Howick which was considered a white people's area. This caused people to lose their homes, livelihoods and dignity as they were forcefully removed (Wagle, 2009; Chili, 2015). The name Mpophomeni describes a waterfall and refers to the Howick Falls. The community has a population of 25731 people occupying 7011 households. It comprises of 30.2% of young children, 66.3% of the working age group and 3.5% elderly citizens (Statistics South Africa, 2011a). Though there is a high number of the working age group, Baiyegunhi and Makwangudze (2013) state that there was an 80% level of unemployment rate in 2007, and the number has increased.

The community is served by the Umngeni Local Municipality under the uMgungundlovu District Municipality with almost every household connected to electricity and tap water in the yard. However, some households situated high up in the hills sometimes do not receive water for weeks and hence, rely on water tankers. Further, most households in this community are poor and food insecure, especially for families with members affected by HIV and AIDS. In South Africa, household food security is highly linked to the household's income capacity, and with the high rates of unemployment prevalence in KwaZulu-Natal, this makes most communities vulnerable to food insecurity. A study by Baiyegunhi and Makwangudze (2013) investigated home gardens and food security in relation to HIV and AIDS households in Mpophomeni and found that about 35% of the households affected by AIDS were severely food insecure.

The infrastructure is characterised as inadequate, with old plumbing and engineering systems in place which are in great parts dysfunctional, and also the population residing in this area exceeding the system's carrying capacity. Illegal dumping and leaking sewer systems are the added issues in this community, all leading to water quality problems. There are 13 schools in the community, which provides an opportunity for the citizens to be enrolled in school for basic education. However, only 3.4% of the people have higher education level (Statistics South Africa, 2011a). This could be the result of not being able to afford tuition fees for higher education and hence leads to a lower human capital.

Though there is high dependence on government grants for households' income, the community has a tourism programme lead by the Zulu-Mpophomeni Tourism Experience (ZMTE) which offers a tour into the township life, the Zulu culture and other activities that tourists appreciate. At the same time this programme aims at empowering the community by showcasing and offering their art and craft work to tourists (Ndlovu et al., 2018). Further, the Ethembeni NGO has also contributed to socio-economic activities of tourism by ensuring that baking, and art works from women in the community are offered to tourists to purchase.

3.1.5 Commonalities and differences between case studies

Each case study has been conducted by a Masters student based at a university with research experience and entry points into the catchment. Room was provided for each student to adapt the design according to their specific research interests and departmental requirements (see Tables 5 and 6).

Table 5 Sets of research methods employed for each case study.

Method	Velddrif (Noordhoek)	Pniel	Lanquedoc	Melani	Hamburg	Sobantu	Mpophomeni
Census data	√	√	√	√	√	√	√
Questionnaire	√	√	√	√	√	√	
Guided conversations						√	√
Resource mapping	√				√	√	√
Focus groups		√	√			√	√
Interviews	√	√	√				
Photovoice						√	√

Table 6 Lenses through which the individual case studies explored how the WEF nexus materialises at the local level.

Case study site	Research angle	Disciplinary focus	Scale(s)	Method
Lanquedoc and Pniel – upper Berg	Assessment of WEF resource access and use by households with different housing structures; and the role of social relations in promoting or impeding access to WEF	Environmental Science	Household and community	Quantitative & qualitative
Velddrif (Noordhoek) – lower Berg	The implications of the WEF nexus on local economic development planning	Environmental Science	Household, community and municipality	Quantitative & qualitative
Mpophomeni – upper uMngeni; and Sobantu – middle uMngeni	Exploring the WEF nexus within communities with a non-payment culture; and scaling of resource provisioning through the hydrological lens	Hydrological Science	Household, community and catchment	Qualitative
Hamburg – lower Keiskamma; and Melani – upper Keiskamma	Description of the WEF status at household level using a water poverty index, multidimensional energy poverty index and household food insecurity access score	Agricultural Economics	Household	Quantitative

3.2 Quantitative methods

3.2.1 Household questionnaire

Through the questionnaire data was obtained on the composition of the households, livelihoods activities, and the access, availability and affordability of water, energy and food. The primary objective was to assess across the sites and catchments the water, energy and food status at household level and to identify specific issues related to the three resources. We also wanted to understand how issues related to one resource may affect the use and access of the other two resources. The questionnaire was the primary entry point of engagement at household level (i.e. for other methods to follow such as focus groups, audits).

For establishing the household food status (we use the word "status" deliberately since a full analysis of all dimensions of food security was not the purpose), we primarily focused on the dimensions of food availability and accessibility (including affordability). The dimensions food utilisation and food stability were not studied through the questionnaire in most cases. However, in the Keiskamma catchment sites, the questionnaire was adjusted to enable the analysis of the Food Insecurity Access Scale (HFIAS Index) (see details in section 3.2.3).

The site-specific household questionnaires for different catchments are included as Appendix 2.

Research and context specific modification of the questionnaire

The project was conceptualised to allow for a fair amount of co-production of the research tools in a catchment-specific contextualised manner. At the start of each study, input from the partner research institutions (the Masters students and their supervisors) as well as other catchment-specific partner organisations was taken into account and the questionnaire adjusted accordingly. This was discussed at research team meetings and partner meetings held during the first few months. The original questionnaire went through a series of iterations for each catchment involving all the site-based team members and in some sites the CRAs and Non-Profit Organisations (NPOs). Consequently, the length of the questionnaire was significantly reduced to avoid stakeholder fatigue and to make it more context specific. Given that the questionnaire was partially administered by the local CRAs some of the more sensitive questions relating to income and food insecurity had to be removed for some sites (primarily in the Berg catchment).

In the uMngeni catchment the communities and the CRAs expressed quite a big discomfort about this type of extractive methodology. Therefore, other options were explored by the KZN research team and the CRAs. Guided conversations were identified as a suitable alternative for generating the required data (see section 3.3.2)

For the Keiskamma catchment sites the household questionnaire was further refined to allow for a more detailed quantitative assessment of the water, energy and food status at household level and related welfare implications.

Despite these research and context specific adjustments in the questionnaire, quantitative comparisons across all the sites and between selected sites was still possible (see sections 3.2.3 and 3.2.4). It did lead to different levels of quantitative analysis for the different catchments / sites, but in catchments where quantitative analysis was by necessity weaker, a stronger qualitative approach was taken (see section 3.3).

3.2.2 Household WEF resource audits

The household resource modelling exercise (energy, food and water use audits) was intended to capture how much energy, water and food resources enter and exit the household on a weekly basis. It was envisioned that the participation in these quantitative audits by household members and the CRAs would be a useful learning tool which would create greater awareness of the systems which deliver energy, water and food to the household, and of opportunities for becoming more resource efficient and realizing household savings. The assumption was that a more efficient resource use (through saving or alternative resource use) would help to reduce trade-offs households have to make. Furthermore, the intention was also to develop and test this approach for possible use by researchers in future WEF nexus projects at household scale.

For energy, the audit built on the household questionnaire instrument which collected data on the energy sources utilized in the households, their specific application and monthly cost. The audit broke this down further in terms of daily electricity usage per appliance, which was then extrapolated to derive a weekly estimate. For water, it included quantifying daily use according to a range of household activities, extrapolating this data to derive a weekly estimate and comparing this to the billed water amount. For food, the intention was to include the quality and quantity of household consumption and different sources of food using the recall method regarding the weekly food basket.

The method of noting the quantity and frequency at point of use in the household was adopted for both water and electricity in separate audits. This considered possible sensitivity around meter reading (issues of non-payment) as well as aiming to raise awareness around WEF resource use and nexus in the household on a daily / weekly scale. Comparing the results from this activity to meter reading was included in the method as the next step which would then segue to the community-scale resource mapping. This would involve interaction with municipal officials where possible and look at longer-term consumption patterns (month) and how these fit into the community scale resource supply and demand.

The household point of use quantity and frequency data was to be collected for a 24-hour period over a minimum of two days (one weekday and one weekend day), but preferably three days. This involved the use of audit sheet templates whereby household members could note their usage down next to an estimated quantity for each use in the case of water, and wattage of the appliance in the case of electricity.

The household audits for water and energy were intended to be conducted across all the sites by each Masters student with the assistance of CRAs (see sections 3.2.2 and 3.4.5). Velddrif (Noordhoek) was used as the first site for detailed method development and roll-out based on the researcher's prior experience with communities in this area of the West Coast. During the Velddrif (Noordhoek) audit, the required training and protocols were to be tested and fine-tuned and the first audit completed, to be followed by the audits for the other case study sites.

During the Velddrif (Noordhoek) process it became increasingly clear that the work was experiencing several significant challenges. These were not foreseen during the project proposal development phase. The following considerations and constraints were encountered:

- The first few audits were conducted in households chosen at random in the community. It soon became clear that the extended contact time required on the part of the CRAs to train the household members to conduct the audit was giving rise to potential safety issues. It was decided to focus on the CRA's households, as well as either a neighbour, friend or family member's household. In this way two to three households per CRA were targeted giving a total of eleven households. This raised concerns around the sampling method and resulting representation of the population which may have introduced bias.

- A high level of involvement and commitment was required of the household members, but this was lacking. In both cases (the water and electricity audits) the data collected from the daily audits was of a poor quality and could not be used as a reliable data source. Some of the CRAs did not secure the participation of the household members, some completed the sheets incorrectly or only partially, and some started off well, then estimated the rest. The process was repeated with additional training, but the results remained poor. Feedback was given by the CRAs that household members complained that they did not have time for completing the sheets and that willingness to participate was low.
- The researchers realised that an audit of what food the household members were consuming daily was intrusive and unwelcome given the sensitivity about poverty and the potential affront on dignity. It was then decided to only include water and energy in the audit. This compromised obtaining a full picture of the WEF status and trade-offs at household level.
- The energy audit was reduced to an electricity audit, as other forms of energy are not simple to quantify at the individual use level. Also, information regarding other energy sources and estimated associated costs was being collected in the questionnaire and inclusion in the audit would have been repetitive.
- It became apparent that the quality of the collected data would not meet the rigorous academic requirements of Masters studies and the students and their supervisors did not see the value of this approach in the academic context and were unwilling to continue investing their limited time.
- The above challenges were compounded by the growing concerns regarding the usefulness of the resource usage data in terms of understanding the household WEF nexus, its interlinkages and trade-offs, and their intersection with livelihoods.
- From other field work activities in Sobantu and Mpophomeni it became clear that conducting an audit would lead to a lot of opposition by these communities. Many of the households are meeting their water and energy needs through illegal connection or through manipulations of their accounts. The audit exercise would be perceived as a form of monitoring and surveillance.
- The preliminary results from the questionnaire or guided conversations also revealed that the potential and capacities of households to change their resource usage (in the form of savings and/or use of alternative resource sources) were either very limited or lacked incentives. The latter related both to the above-mentioned culture of non-payment and to the perceived lack of benefits resulting from possible household efforts to become ‘more efficient’.

- Resources and focus on CRA households limited the sample size, inadequate resources for a larger sample size.
- Finally, the project resources were insufficient for the very high levels of time and money that would have been needed to address the challenges and achieve the envisaged outcomes. This would have required increased training of the CRAs and the household members, a proper sample size for each community (beyond the CRA's circle), significant time and money for travel, accommodation and subsistence for the Masters student, and other measures to generate good quality reliable data such as increased trust and buy-in (with no guarantee of these outcomes). The researchers concluded that the value for money was not going to be justifiable given the project constraints.

Following discussion amongst the research team members, it was decided that the household WEF resource audits could not be continued. Instead, the researchers would seek to identify and pilot an alternative tool at the community level with linkages to the household experience, that would complement the other tools employed (in the context of understanding the nexus and its pressure points and interlinkages) and also serve the need to assist in WEF nexus awareness raising and learning. The new approach, 'mapping WEF resource supply systems' was discussed with the Project Reference Group who were at first concerned by this change (and loss of quantitative data) but were willing to accept the change on the basis of the strong potential social benefits and the potential to scale the underlying approach to other WRC research projects.

The impact on the project of abandoning the household audits may include:

- One of the quantitative data generation tools was lost, and its replacement was not a quantitative tool (this was compensated by the multi-criteria statistical analysis described in section 3.2.3);
- Information at the individual household level was lost, and its replacement had a stronger focus on the community level;
- However, the quality of information gained from the replacement was high and valuable to the overall research project.

3.2.3 Statistical analyses

The following statistical analyses were conducted. The hierarchy of these analyses is presented diagrammatically in Fig. 3.

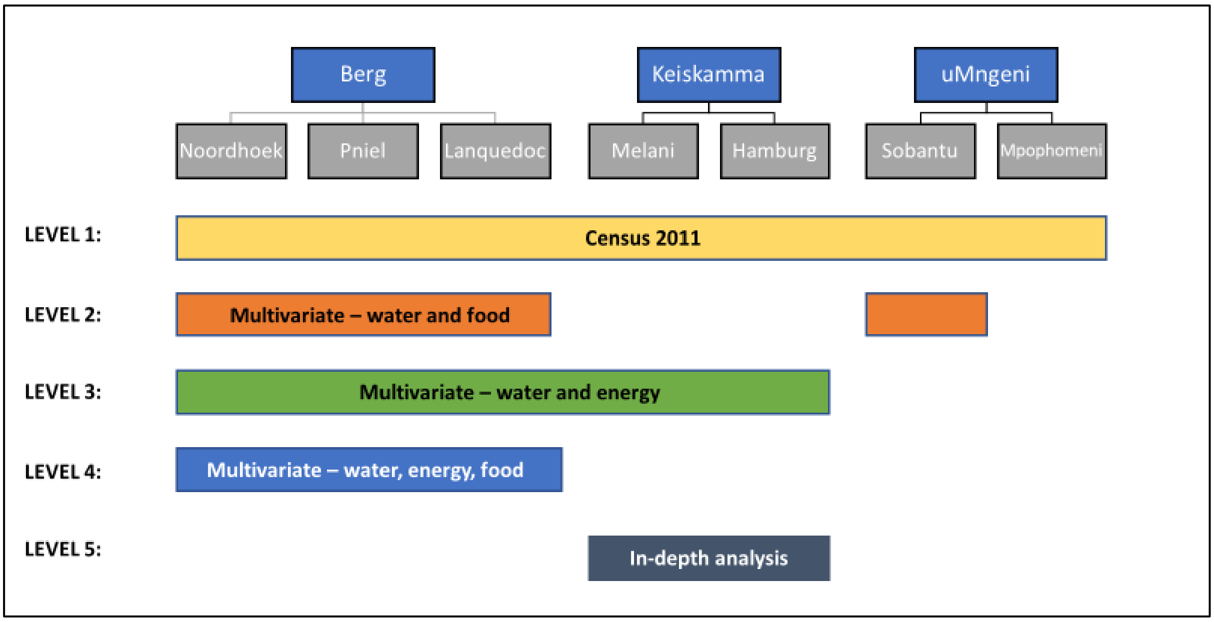


Figure 3 Diagram of the hierarchy of quantitative analyses conducted across catchments and sites.

Level 1: Census indicators

The South African National Census 2011 was used for the extraction of sub ward-level data on household characteristics and indicators relating to water, energy and food at household level in each of the seven sites. Census 2011 remains the most recent national census and was chosen for consistency in methodology across all the sites, so that comparisons may be made between catchments and between sites. More recent household surveys frequently are not available at very high spatial resolution (ward level) across the whole country, or cover only certain aspects, e.g. health, food security.

An important difference between census data and the project's research using a site-specific household questionnaire, is that the questionnaire is based on a limited random sample in the community whereas the census aims to capture the whole population.

Census data was used for four reasons:

1. The site-specific household questionnaires could not elicit certain information on household socio-economic and WEF characteristics.
2. To provide a sense-check of the reliability of results gained from the household questionnaire which was based on a smaller sample.
3. To provide a rapid top-down lens on the socio-economic status and nexus-related status in each site which was used to identify possible WEF nexus 'pressure points' or trade-offs and helped to fine-tune the research methodologies.
4. To provide additional and supplementary data for the development of indices for the five livelihoods capitals/assets.

Level 2: A comparison of four communities in the Berg and uMngeni catchments

Data from one community in the uMngeni Catchment, KwaZulu-Natal (Sobantu – 50 households) and three in the Berg Catchment, Western Cape (Pniel – 50 households, Lanquedoc – 63 households, and Noordhoek – 92 households) were subjected to multivariate analysis (n=255). From these four communities, 18 variables collected through interviews were converted into categorical and binary data (resulting in 31 columns/variables). These 18 variables were composed of household level contextual information (9 variables, 20 columns), and variables relating to water (1 variable, 1 column), and food (8 variables, 10 columns). The 255 households were screened for observations (households) which had a high number (>3) of missing values. Six households were removed, five from Noordhoek and one from Pniel. The resultant 249 observations of 31 variables were subjected to Hierarchical Clustering on Principal Components (HCPC), which combines Multiple Correspondence Analysis (MCA) with Hierarchical Clustering. The MCA step serves to analyse the multidimensional categorical variables and their relationships and to pre-process the data so that a subsequent hierarchical cluster analysis can be performed on the categorical data. The HCPC was run with the FactoMineR R package and the FactoExtra R package was used for data visualisation (Le et al., 2008; R Core Team, 2016; Kassambara and Mundt, 2019). Results are presented for three levels of analysis: (i) First, all variables (100% of data) were used in the MCA and hierarchical clustering to create clusters (types) of households that share similar characteristics. Second, all variables from the (ii) household level contextual information were analysed separately, followed by (iii) water and food-related variables. For each of these three levels of analysis, the statistical contribution of variables to explaining cluster separation (all clusters together) was assessed and non-significant variables were identified and removed from the data set. The MCA and hierarchical clustering analyses were then re-run. The resulting dendrograms were cut into a certain number of clusters based on the results. The significance of the variables in explaining the clustering was assessed for all clusters combined, and for each of the resultant individual clusters.

Level 3: A comparison of five communities in the Berg and Keiskamma catchments

Data from two communities in the Keiskamma Catchment, Eastern Cape (Hamburg – 142 households and Melani – 141 households) and three in the Berg Catchment, Western Cape (Pniel – 50 households, Lanquedoc – 63 households, and Noordhoek – 92 households) were subjected to multivariate analysis (n=488). From these five communities, 14 variables collected through interviews were converted into categorical and binary data (resulting in 21 columns/variables). These 14 variables were composed of household level contextual information (5 variables, 7 columns), and variables relating to water (4 variables, 4 columns), and energy (5 variables, 10 columns). The 488 households were screened for observations (households) which had a high number (>3) of missing values. Six households were removed, five from Noordhoek and one from Pniel. The resultant 482 observations of 21 variables were subjected to Hierarchical Clustering on Principal Components (HCPC), which combines Multiple Correspondence Analysis (MCA) with Hierarchical Clustering. The MCA step serves to analyse the multidimensional categorical variables and their relationships and to pre-process the data so that a subsequent hierarchical cluster analysis can be performed on the categorical data. The HCPC was run with the FactoMineR R package and the factoextra R package was used for data visualisation (Le et al., 2008; R Core Team, 2016; Kassambara and Mundt, 2019). Results are presented for only one level of analysis: all variables (100% of data) were used in the MCA and hierarchical clustering to create clusters (types) of households that share similar characteristics. The statistical contribution of variables to explaining cluster separation (all clusters together) was assessed and non-significant variables were identified and removed from the data set. The MCA and hierarchical clustering analysis were then re-run. The resulting dendrogram was cut into a certain number of clusters based on the results. The significance of the variables in explaining the clustering was assessed for all clusters combined, and for each of the resultant individual clusters.

Level 4: A comparison of three communities within the Berg catchment

For the three Berg communities (n=205), Pniel (50 households), Lanquedoc (63 households) and Noordhoek (92 households), 36 variables (1 continuous and 35 categorical) were converted into categorical and binary data (resulting in 51 columns/variables). These 36 variables were composed of household level contextual information (12 variables, 22 columns), and variables relating to the water (11 variables, 11 columns), energy (5 variables, 9 columns) and food (8 variables, 9 columns) nexus. The 205 households were screened for observations (households) which had a high number (>3) of missing values. Six households were removed, five from Noordhoek and one from Pniel. These 199 observations of 51 variables were subjected to Hierarchical Clustering on Principal Components (HCPC), which combines Multiple Correspondence Analysis (MCA) with Hierarchical Clustering. The MCA step serves to analyse the multidimensional categorical variables and their relationships and to pre-process the data so that a subsequent hierarchical cluster analysis can be performed on the categorical data. The HCPC was run with the FactoMineR R package and the factoextra R package was used for data visualisation (Le et al., 2008; R Core Team, 2016; Kassambara and Mundt, 2019). Results are presented for five levels of analysis: (i) First, all variables (100% of data) were used in the MCA and hierarchical clustering to create clusters (types) of households that share similar characteristics. Second, all variables from the (ii) household level contextual information were analysed separately, followed by (iii) water-related variables, (iv) energy-related variables, and (v) food-related variables. For each of these five levels of analysis, the statistical contribution of variables to explaining cluster separation (all clusters together) was assessed and non-significant variables were identified and removed from the data set. The MCA and hierarchical clustering analyses were then re-run. The resulting dendrograms were cut into a certain number of clusters based on the results. The significance of the variables in explaining the clustering was assessed for all clusters combined, and for each of the resultant individual clusters.

Tables 7 and 8 summarise the sets of variables used for each analysis. All the variables/columns with their codes and descriptions are presented in Appendix 3, Table 32.

Table 7 The number of common variables used in each of the four categories, and in total, for each level of analysis.

Variables	Household	Water	Energy	Food	Total
Level 2: Berg & uMngeni	9	1	0	8	18
Level 3: Berg & Keiskamma	5	4	5	0	14
Level 4: Berg	12	11	5	8	36

Table 8 The number of resultant columns (i.e. from converting some variables into binary options) for the four categories, and in total, for each level of analysis. The last column therefore shows the final number of variables used in the analysis.

Columns	Household	Water	Energy	Food	Total
Level 2: Berg & uMngeni	20	1	0	10	31
Level 3: Berg & Keiskamma	7	4	10	0	21
Level 4: Berg	22	11	9	9	51

Level 5: In-depth comparison of two communities within the Keiskamma catchment[5]

The overall objective of this study was to explore the welfare implications of the water-energy-food (WEF) nexus at household level using the case of Hamburg and Melani communities in the Keiskamma catchment of the Eastern Cape Province. This section summarises the methods employed for the in-depth analysis of the data gathered. Full details of the methods are presented in Ningi (2020).

The study used a mixed method approach (Creswell et al., 2011). The survey looked at the household's security status (water, energy, and food), demographic information of the household, and agricultural activities performed by the households. The study made use of a questionnaire as the main instrument of data collection on the factors affecting the status of water, energy, and food of households. Moreover, the study also used focus group discussion to obtain explanations of the issues captured in the main questionnaire. Two focus groups were conducted to collect qualitative data, namely, people's knowledge of the water-energy-food nexus and their welfare.

The study employed a purposive random sampling technique, and 280 households were selected for direct questioning, comprising 140 households from Melani and 140 from Hamburg. The sample size was calculated for a margin of error of 5% for 945 households. The unit of analysis for the study was the household head.

Three indices were calculated for households and communities, with details given in Ningi (2020):

[5] This section is a contribution of Thulani Ningi and forms part of his Masters thesis.

1) Water Poverty Index (following Sullivan, 2002) where WPI=100 means that a household is water secure and WPI=0 means that a household is water insecure.
   The WPI was then used as a dependent variable on the ordinary least squares (OLS) linear regression to evaluate the factors that affect household water security status in the study sites.
2) Multidimensional Energy Poverty Index (Nagothu, 2016) where the closer the MEPI is to 1 the lower the energy poverty level for the household, and the closer the MEPI is to 0 the higher the level of energy poverty is.
   The MEPI was then used as a dependent variable on the ordinary least squares (OLS) linear regression to evaluate the factors that affect household energy security status in the study sites.
3) Household Food Insecurity Access Scale (Coates et al., 2007) where the higher the HFIAS score, the higher the probability of the household being food insecure.
   Factors influencing household food security in the study area were analysed using an ordered logit regression model following Nengovhela et al. (2018). The study made use of the HFIAS ordered categories n= 1 (food secure: 0-6), n= 2 (mildly food insecure: 7-13), n= 3 (moderately food insecure: 14-20) n= 4 (severely food insecure: 21-27) as the dependent variable on the Ordered Logit regression in order to determine the factors influencing the household food security in the study area.

Thereafter, the Spearman rank correlation test was used to measure the relationships between; (a) water security and food security, (b) energy security and food security and (c) water-energy security and food security.

3.2.4 Integrating livelihood assets and WEF at household level: indicators and indices

There is global interest in developing analytical tools that can help to operationalise the WEF nexus in terms of policy development, programmatic planning and management, including monitoring and evaluation. Several such tools have been developed (Daher and Mohtar, 2015; Endo et al., 2015; Albrecht et al., 2018; Fernandez-Torres et al., 2019). In this study we tested a method using indicators and composite indices to capture the livelihood-WEF interconnections at local scale, and which could be developed into a practical decision-support and planning tool. Nhamo et al. (2019) developed such a tool by first identifying WEF nexus sustainability indicators, then calculating and integrating indicator indices, and, finally, developing a WEF nexus analytical model. This was tested for the South African case, at national level.

In this study, a simple methodology was developed to calculate indices for each of the five sustainable livelihood ‘capitals’, namely, financial, physical, human, social and natural, at the household level. Indicators were chosen at the intersection between livelihood capitals and WEF, i.e. each indicator contributed to a certain livelihood capitals class but was simultaneously a significant determinant of household WEF security as shown by the results of this study. The data was sourced from both the case study data sets, the Census 2011 data set, and site-specific expert agreement (qualitative information) for one variable (social cohesion) and a few missing data points for quantitative variables. The ‘expert’ groups were comprised of the following people (Table 9):

Table 9 Experts used to discuss the indicator ‘social cohesion/trust’ for each community, and to fill in gaps in quantitative using qualitative assessment.

Berg catchment	Keiskamma catchment	uMngeni catchment
Ms Penny Price – youth coordinator and student with the project (Noordhoek); many years’ experience working in Berg catchment communities Dr Nadine Methner – project leader and student supervisor (Pniel/Lanquedoc) Prof Stephanie Midgley – researcher with extensive knowledge of the region; analyst	Mr T Ningi – student with the project working in these communities Dr L Zhou – student supervisor and many years’ experience working with these communities Ms Carol Hofmeyer – previously Keiskamma Trust and 20-year resident of Hamburg Dr Nadine Methner – project leader Prof Stephanie Midgley – researcher and analyst	Ms N Nxumalo – student with the project working in these communities Dr S Stuart-Hill – student supervisor and many years’ experience working with these communities Ms L Taylor – EnviroChamps, DUCT, and many years’ experience working with the Mpophomeni community Dr Nadine Methner – project leader Prof Stephanie Midgley – researcher and analyst

This analysis was not foreseen or planned at the start of the project; thus, the method was not based on a conceptual framework or published research. Rather, measurable sustainability indicators were selected *post hoc* according to the following criteria:

- The indicator was available in the census and/or case study data set for all seven sites. Unavailability of data in the case study data set (sometimes Mpophomeni and sometimes the Keiskamma sites and/or Sobantu did not provide the indicator) was accepted if a clear rank for the indicator could be decided on the basis of simultaneous census data availability for all sites, or it was possible to estimate a rank using expert agreement (see Table 9). The only exception was the indicator ‘social cohesion’ which was ranked only by expert agreement.
- The indicator was shown to have a direct bearing on household-WEF situations through the quantitative analysis presented in section 3.2.3. The only exception was ‘cohesion and trust’ as an indicator for ‘social capital, but this indicator was part of the in-depth qualitative analyses for Pniel and Lanquedoc described in section 5.3.1.

Other potential indicators were identified through the various analyses in this study but could not be included due to differences in the research methodologies between the sites. Examples include ‘number of household members contributing to combined household income’ (including the mixing of pensions, grants, and various frequencies of employment), 'duration of residence in the community', 'proportion of income spent on water, energy and food', and detailed data on the contribution of food gardens to food security. The selected set of indicators used here is thus indicative only, to test the approach, and other combinations of indicators could be tested. It is important to note that the set of indicators was not statistically tested.

Many of the indicators are already available through the national Census and other surveys such as the National Household Survey, and many are linked to the SDG indicators (see Saladini et al., 2018; Nhamo et al., 2019). The indicators for WEF affordability and WEF 'demand met' have been shown in this study to be critical for an assessment of WEF-livelihood relationships at household level but are not readily available through standard surveys. Equally, indicators for 'social capital' such as household and community cohesion and trust are more difficult to assess but are very important in all communities.

Each indicator was assigned a rank between 1 and 10, as described in Table 10. A composite 'capitals index' was calculated as the arithmetic mean of the contributing indicator ranks. Finally, an overall composite 'livelihood-WEF index' was calculated as the arithmetic mean of the five 'capitals indices'.

Table 10 Indicators used for the calculation of indices for each of five livelihood capitals (with WEF linkages), their descriptions and units, sources of data, method of arriving at a relative rank, and rationale for the choice of indicator.

Livelihood capital	WEF category	Indicator	Definition / unit	Source	Ranking method	Rationale
Financial	Household	1. Employment status	Persons who work for pay, profit, or family gain, in the reference period: % of population	Census 2011	1 to 10 based on deciles, using both data sources	Employment contributes positively to financial capital
			Head of household employed: % of households	This study Not available: Mpophomeni		
	Household	2. Household income	Average annual household income: % of households with income ≥R38 201 per annum	Census 2011	1 to 10 based on deciles	A higher annual household income contributes positively to financial capital
	Energy	3. Energy affordability trend	Change in electricity affordability over the years that they have lived there: % of households responding “declined”.	This study Not available: Mpophomeni and Sobantu (non-payment culture) – rank estimated using expert opinion	1 to 10 based on deciles	A lower % “decline” contributes positively to financial capital
Physical	Water	1. Source of water	Source of water: % of households receiving water from a regional/local water scheme (operated by municipality or other water services provider)	Census 2011	1 to 10 based on deciles	Access to scheme water contributes positively to physical capital
	Water	2. Water demand met	Household water demand is met: % of households responding “yes”	This study Not available: Mpophomeni and Sobantu – rank estimated using expert opinion	1 to 10 based on deciles	Water demand met contributes positively to physical capital
	Water	3. Drinking water source inside	Source of drinking water is inside the dwelling: % of households	This study Not available: Mpophomeni – rank estimated using expert opinion	1 to 10 based on deciles	Water source inside contributes positively to physical capital
	Energy	4. Electricity connection	Electricity used for lighting: % of households	Census 2011	1 to 10 based on deciles, using both data sources	Electricity connection contributes positively to physical capital
			Electricity used for lighting: % of households	This study Not available: Mpophomeni		
	Water	5. Flush toilet	Toilet facility – sum of % Flush toilet (connected to sewerage system) and % Flush toilet (with septic tank) per household	Census 2011 Not available: Mpophomeni and Sobantu	1 to 10 based on deciles, using both data sources	Use of flush toilet contributes positively to physical capital
			Toilet facility — sum of % Communal flush and % Own flush, per household	This study		
	Household	6. Formal dwelling	Type of main dwelling is formal: % of households	Census 2011	1 to 10 based on deciles, using both data sources	Formal/brick/cement/ wood dwelling contributes positively to physical capital
			Type of dwelling structure is brick, cement or wood: % of households	This study		

Livelihood capital	WEF category	Indicator	Definition / unit	Source	Ranking method	Rationale
				Not available: Mpophomeni, Sobantu, Melani, Hamburg – rank estimated using expert opinion		
	Energy-Food	7. Electric/gas stove	Use of electric or gas stove: % of households	Census 2011 Not available: Mpophomeni and Sobantu	1 to 10 based on deciles, using both data sources	Use of electric / gas stove contributes positively to physical capital
			Use of electric or gas stove: % of households	This study		
	Energy-Food	8. Refrigerator	Use of refrigerator: % of households	Census 2011	1 to 10 based on deciles	Use of refrigerator contributes positively to physical capital
Human	Household	1. Education level	Sum of % values for categories some secondary, matric, less than matric with cert/dipl, matric and cert/dipl, advanced degree: % of households	Census 2011	1 to 10 based on deciles	Higher level of education contributes positively to human capital
	Household	2. Younger population	Age groups: sum of % for 0-14 yrs and % for 15-64 yrs (thus excluding % for ≥65 yrs)	Census 2011	Ranking as follows: 87.5-90%=6 90-92.5%=7 92.5-95%=8 95-97.5%=9 97.5-100%=10	A higher proportion of younger people signifies greater health and life expectancy which contributes positively to human capital
Social	Household-community	1. Social cohesion / trust	Rankings were agreed after joint discussion with team members working in the various sites, their academic supervisors, and local expert informants involved with the communities over many years.	This study	1 to 10 based on deciles	Higher level of social cohesion / trust contributes positively to social capital
Natural	Energy-food	1. Use of wood for heating/other purposes	Wood used as energy or fuel for heating: % of households	Census 2011	Ranking as follows: 0-2%=1 2-4%=2 4-6%=3 6-8%=4 8-10%=5 10-12%=6 12-14%=7 14-16%=8 16-18%=9 18-20%=10	Higher level of wood for heating and other household energy uses contributes positively to natural capital
			Use of wood for various purposes (overall source of energy): % of households	This study Not available: Mpophomeni and Sobantu – rank estimated using expert opinion	1 to 10 based on deciles	

Livelihood capital	WEF category	Indicator	Definition / unit	Source	Ranking method	Rationale
					Final ranking = average of two rankings	
	Energy	2. Use of manure for energy	Use of manure for various purposes (overall source of energy): % of households	This study Not available: Mpophomeni and Sobantu – rank estimated using expert opinion	Rankings as follows: 0%=1 0.1-5%=2 5-10%=4 10-15%=6 15-20%=8 20-25%=10	Higher level of manure for various household energy uses contributes positively to natural capital
	Food	3. Foraging for food	Engage in foraging for food: % of households	This study Not available: Melani, Hamburg and Mpophomeni – rank estimated using expert opinion	Rankings as follows: 0%=1 0.1-5%=2 5-10%=4 10-15%=6 15-20%=8 20-25%=10	Higher level of foraging contributes positively to natural capital
	Food	4. Fishing for food	Engage in fishing or harvesting of other seafood to sell or for food: % of households	This study Not available: Melani, Hamburg and Mpophomeni – rank estimated using expert opinion	Rankings as follows: 0%=1 0.1-5%=2 5-10%=4 10-15%=6 15-20%=8 20-25%=10	Higher level of fishing or seafood harvesting contributes positively to natural capital
	Food	5. Farming for food	Engage in farming (keeping of livestock or small-scale farming): % of households	This study Not available: Berg and uMngeni – rank estimated using expert opinion	Rankings as follows: 0-5%=1 5-10%=2 10-15%=3 15-20%=4 20-25%=5 25-30%=6 30-35%=7 35-40%=8 40-45%=9 45-50%=10	Higher level of farming contributes positively to natural capital
	Food	6. Growing food (garden)	Engage in the growing of own food in a garden: % of households	This study Not available: Melani, Hamburg and Mpophomeni – rank estimated using expert opinion	1 to 10 based on deciles	Higher level of food gardening contributes positively to natural capital

3.3 Qualitative methods

Several qualitative analyses were conducted across the case study sites as presented diagrammatically in Fig. 4.

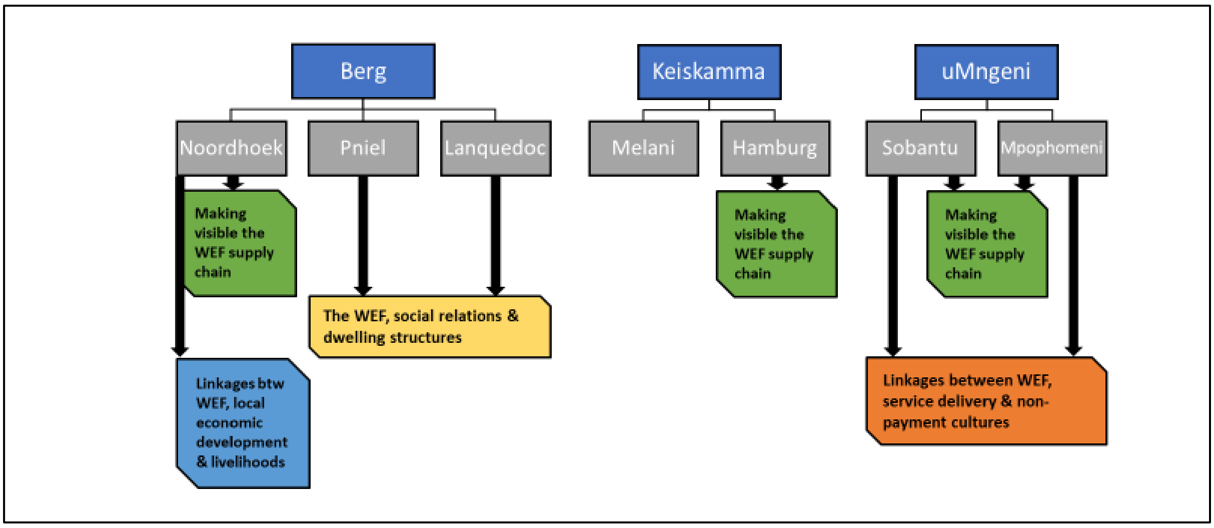


Figure 4 Diagram of the qualitative analytical approaches taken for each catchment and site.

3.3.1 Mapping WEF resource supply systems at community level

Results from the household questionnaires and guided conversations provided an initial assessment of the livelihoods and household WEF statuses. This provided a valuable insight into household level WEF resource availability, access and to some degree, usage, as well as livelihoods. Although this pointed to some degree of trade-offs between the WEF resources at this scale, as well as a glimpse of the interlinkage with livelihoods, the spatial scale needed to be expanded beyond the household in order make the nexus and the interlinkages more visible. Resource mapping, which involved the tracing or 'making visible' of the systems or 'chains' that supply WEF resources to households, was introduced into the project design These systems are defined as being the infrastructure and in some sites this touched on the related governance, both formal and informal, that supply, or are used to source, resources to the household, particularly in the case of water and energy. Food is typically purchased by the householder from a retail outlet, again both formal and informal, or own produce grown / raised.

The aim of the resource mapping was as follows:

1. To map the water, energy and food resources and flows from the household scale to the community-scale and beyond where relevant, in order to gain a deeper understanding of the availability and access to WEF resources in the research sites, as well as making visible any significant nexus points on a community scale that may have relevance at the household scale (the primary scale of focus of the study).
2. To facilitate a meeting of different knowledges around the WEF resources and nexus through the exchange of knowledge between academic and non-academic actors in line with trans-disciplinary research.

3. To encourage active citizenry through the 'making visible' of local WEF resource flows, actors and dependencies. This is based on the premise that increased visibility and knowledge of resource limitations, availability and access issues would encourage informed engagement with resource management.
4. To ensure a local repository of WEF resource-related information both in the form of visible media through the production of maps, as well as embodied in members of the community (youth).

The approach taken was to work from the household out into the supply system. For example, in the case of the water resource, the municipal water supply was mapped from the household water meter outwards to the local reservoir and from there to the bulk water supplier and beyond to the source of their water, which included boreholes and dams on rivers. The role of electricity in this 'water supply chain' was noted as the mapping took place assisted by input from managers and experts. Any intersection with the food system was also noted, for example in the lack of water being available to the fish processing factory in the Lower Berg site precipitated by the drought in the area in 2015-2018.

The resource mapping utilised participatory mapping techniques, learning journeys and expert interviews as data collection methods. The participatory mapping technique included the CRAs, and in some sites, additional community members, in drawing a WEF nexus map of the research site and beyond if local knowledge extended this far. The WEF nexus map was built up iteratively as information was collected about the respective systems and how and where they intersect to form nexus points. This gathering of information was achieved through a combination of learning journeys hosted by managers of these systems, ground truthing through walk/drive around combined with GPS mapping, and expert interviews with key actors in the supply chains. Further detail of the processes involved is contained in section 3.4.6.

3.3.2 Guided conversation[6]

Guided conversations were identified as a suitable alternative to the questionnaire for generating the required data in the uMngeni sites. This was achieved through a shared reflection process with household members surrounding the themes of WEF resource scarcity, demand, utilisation and affordability, as well as livelihoods. The method allowed for an interactive, exploratory style characterised by the sharing of information and perspectives rather than the more inquisitorial style associated with traditional questionnaires. This was more conducive to open and candid information sharing around topics that could be deemed as sensitive, particularly around issues of personal dignity and in cases of non-payment for services. It also allowed the participants to see a bigger picture with their inputs being part of the answers/solutions or action towards providing solutions for issues affecting them or their community. The number of households that participated in the guided conversations were 50 for each research site (i.e. Mpophomeni and Sobantu). Regarding the selection of these

[6] This section is a contribution of Ntombiyenkosi P. Nxumalo and forms part of her Masters thesis.

households, the study followed a convenient and purposive sampling method. This method was selected because it was anticipated that not all households would be willing to participate in the study especially since it investigates their livelihoods. Hence, the study selected the participants conveniently, according to their availability and willingness to participate. Their decision to participate was guided by the consent form which was translated into isiZulu; the conversations were also held in isiZulu to ensure greater comfort.

3.3.3 Focus groups

Focus group discussion is a common tool used to engage with multiple stakeholders to discuss social related issues. This tool is useful to gather information on different perspectives, regarding a certain topic that influences the way we interact with each other. Further, this method has a potential to produce rich data from discussions about sensitive issues, such as poverty, corruption, theft, unemployment, etc. Focus groups where used as a tool at the cross-section between household and community level and in the uMngeni sites at the cross-section between community and decisionmaker level.

Household/community interface[7]

For the research sites in the Upper Berg catchment (Lanquedoc and Pniel) the focus groups were formulated to gain insights into how social relations contribute to water, energy and food access. For the purposes of this study, the work of Fiske (1992; 2004) was the point of departure. Social relations, as defined by Fiske (1992:689), refers to the "process of seeking, making, sustaining, repairing, adjusting, judging, construing, and sanctioning relationships". Fiske (2004) further elaborates on the application of the relational model theory, emphasising the 4 relational components (Community Sharing, Authority Ranking, Equality Matching, Market Price) that outline how people relate to each other. Social relations have been observed to operate beyond the household level. Thus, a community engagement through a focus group setting was sought to explore existing relations in more detail. Morgan and Hoffman (2018) further advise that if the outcome is to investigate consensus and diversity in a group, focus group discussions are well suited. Thus, bringing together a variety of voices in a focus group representing the households assisted in answering questions about the dynamics that are involved in both the community and household as far as social relations and the WEF nexus are concerned.

Furthermore, the aim of this section of data collection was to understand what social relations are present in these communities and how these social relations are used to withstand (or contribute to the succumbing to) shocks and stressors in the form of insecurities (i.e. water-energy-food insecurities). The first step was to assess the types of social relations present within the community, how these are used to access water, energy and food resources, and whether such relations can also inhibit access to WEF resources in the two communities. See Appendix

[7] This section is a contribution of Vumande Mjanyelwa and forms part of her Masters thesis.

4 for information on participant selection and the questions that guided the focus group conversations.

Community/ decisionmaker interface[8]

Focus groups in the uMngeni sites with NGOs/ Community Based Organisation (CBOs), ward councillors, other community leaders where used to enquire into trends and bigger interacting drivers affecting household resource use and availability as well as to identify and map jointly the key structures and role players.

The issues of social deprivation and resources (in)security is common in the townships and it has been a challenge for both citizens and service providers. Often, the experiences on the ground are not fully understood at a higher level, also, the challenges encountered at a higher level where decision are made regarding resources supply are not clearly and fully understood by the consumers. Thus, it is essential to engage all stakeholders at different scales of governance, i.e. household, community, and a broader catchment scale to participate in matters influencing resources scarcity, security and supply. Considering that, water, energy and food resources are interlinked and their (in)security has implications on livelihoods, a cross-scale engagement seems fitting to discuss issues related to the WEF nexus and the interdependencies that exist between the three resources. A cross-scale analysis will provide a better understanding of where the nexus is strongly represented and identification of any disjoints and gaps that may exist between these scales. To gather information from stakeholders' participation at different scales, the study carried out three focus group meetings, i.e. with an NGO called Ethembeni, the Sobantu War-Room committee and a group of key catchment decisionmakers.

The purpose of these focus groups was to explore different perspectives and a broader overview of the role of these organizations and their stakeholders within the catchment, and especially to understand strategies they have developed in order to ensure service delivery of these three resources.

Ethembeni (meaning bringing hope) NGO was identified for a focus group discussion for this project because of current running programmes with an interest on two of the four; namely, (i) a family support programme which has grown to a more integrated intervention that now includes food security, income generation and other healthcare support, and (ii) the Mpophomeni Family Centre which is working with vulnerable children and other project carried out jointly with AIDS Foundation of South Africa (AFSA). This engagement proved to be significant because not only does it touch on livelihood issues but also food security which may be connected to water and energy security directly and or indirectly.

Sobantu War-Room: A war-room refers to the mandated meetings attended by different stakeholders, inclusive of governmental officials involved in the provision of service delivery within the community. This group of stakeholders were identified for this study because, they

[8] This section is a contribution of Ntombiyenkosi P. Nxumalo and forms part of her Masters thesis.

have a direct contact with the community as the community brings all the service delivery issues to the war room. A clear understanding of the War-Room and its role was envisioned, also the strategies used to ensure service delivery in a particular community. These meetings are usually chaired/led by a ward councilor and issues of government grant registrations, food parcels, safety and security, health, etc. are discussed. This provided an opportunity to engage the group on the topic of the WEF nexus and the impacts it has on livelihoods and vice versa.

The decisionmakers focus group was set specifically to explore a broader view on the WEF nexus and its resources. This format of an inquiring conversation enabled a better understanding of the role of each attending representative, their respective organisation and other stakeholders within the catchment regarding their developed strategies to ensure service delivery of the three WEF resources. The organisations attending the decisionmakers focus group were DWS, Umgeni Water, WWF, DUCT and UEIP. For this project it was of great interest to gain insights into the decisionmakers experiences and what strategies have succeeded and what the encountered challenges were and are. The discussion aimed to explore how the WEF nexus affects the decision-makers' operations and what strategies have been implemented to ensure resource delivery.

3.3.4 Photovoice[9]

Scientific research regarding service delivery of the three basic resources, water, energy and food, occurs within a specific context and is dominated by its political setting and related conditions (Debbané and Keil, 2004; Bond and Dugard, 2008; Castleden and Garvin, 2008). These conditions prove to be closely linked to socio-political issues of the past, where some people were deprived of these resources. For example, the old South African Water Act (Act No 54 of 1956) linked water rights to land tenure, thus, meaning a lack of water access when land was not owned. Leaving this trajectory of ongoing inequality, injustice, and marginalization proves very difficult (Castleden and Garvin, 2008). As a result, researching within disadvantaged and poor communities is a challenge and requires methods that are more empowering to the communities and can build trust. Only then true or rather reality congruent data and relations can be gathered and understood in context.

Stakeholders' involvement and community participation is such an approach that empowers people instead of an extractive study that gathers data without understanding context. Stakeholder involvement and community participation take cognizance of issues of concerns such as inequalities, poverty, etc. and in the course of the involvement and communication enables learning from each which can lead to empowerment. To undertake a study regarding water, energy, and food resources (in)securities in disadvantaged and poor communities, this is therefore the ideal approach to employ. This is especially true in townships where discussions relating to energy and water are a sensitive issue as it links to the financial capacity of a household to be able to pay for such services. According to Pierce (2020) and (Lopez et al.,

[9] This section is a contribution of Ntombiyenkosi P. Nxumalo and forms part of her Masters thesis.

2005) photovoice is a useful tool that can assist with the empowerment of vulnerable local communities as it reflects their own perceived reality and shows context beyond the individual resources. Therefore, photovoice as a tool provides an excellent setting for this study, which aims to explore the WEF nexus to better understand how it affects the livelihoods at a household level within the communities of non-payment culture in the uMngeni catchment.

Photovoice is a visual and participatory action research method that uses graphics to encourage community empowerment and social change (Wang and Burris, 1997; Wang and Pies, 2004; Liebenberg, 2018; Derr and Simons, 2020). As a knowledge and empowerment tool, photovoice was designed based on three objectives, namely; (i) to assist community members to document and reflect on the issues they have, while identifying their community strengths and weaknesses, (ii) to promote learning and knowledge transformation through group discussion about community concerns and how they impact their livelihoods, using photographs, and (iii) to potentially reach decision-makers and further inform policy which is hoped to bring change to the identified issues (Wang and Burris, 1997; Wang, 2003, 2006; Derr and Simons, 2020). For this reason, the study utilised the photovoice tool to map, analyse and understand the impacts of resource scarcity around water, energy, and food on sustainable livelihoods and vice versa in two township areas.

The method was employed in two communities of similar socio-economic settings, the Sobantu, and Mpophomeni communities, classified as urban and peri-urban areas, respectively. The two sites were chosen based on their socio-economic status, which is deemed to be under the poverty line, with high rates of unemployment and most of the poor households highly dependent on government social grants. Further, the Sobantu and Mpophomeni communities are said to be non-payment culture communities, meaning that, they do not pay for their basic services. Illegal electricity (energy) and water connections are common. The photovoice method was used to gain a better understanding of the availability of the three resources (WEF) as well as the communities' accessibility and utilisation thereof. Further, the data gathered aimed at getting a clearer understanding of the linkages and interdependencies amongst the three resources at a household level.

There are four key outcomes that were anticipated by employing above methods. These were:

- The youth's understanding of the characteristics of the WEF nexus at a local scale through participatory activities.
- Testing the effectiveness of the photovoice methodology for community empowerment.
- Building interests and willingness to participate in environmental sustainability activities.
- The ability of the community to realise and reflect on the issues / challenges they are encountering and to then come up with adequate solutions.

Photovoice uses participatory processes to learn about our surrounding using photos and drawings. It was used in this study as a tool to enable visualization and express previous experiences regarding the availability, access, affordability and utilisation of the three resources within the Mpophomeni and Sobantu communities. Participants for this study were two youth groups from each community. A one-day workshop was held in the community hall with each youth group to train them on the photovoice methodology and what tools are needed to complete a photovoice exercise. During the workshop, a scenario of water harvesting was used to better describe the photovoice methodology. Here, the importance of collecting rainwater that can be used for household domestic activities and gardening was illustrated. For the attendees this was an interesting example; however, most of them were concerned about the affordability of water tanks within their communities. The workshop was a success as it became clear what the photovoice method was about, how it can be used and how it serves as an empowerment tool.

The two youth groups were divided into small groups of four each, i.e. four groups per site (Mpophomeni and Sobantu) and tasked to work together throughout the exercise. The exercise was done over a time span of two weeks. To take photographs, the participants used the cameras on their phones and were provided with at least one computer as a group to write a report based on their photographs; some of the groups made posters. This again improved their technical skills, writing skills and creativity. After the two weeks the groups met with their counterparts of the same township and had a two-hour discussion about what they saw and learned. They also discussed what needed to be done moving forward to provide solutions for the previously identified issues around the WEF nexus. This was recorded by each group who chose one of their members to write down all the key points discussed during this youth engagement.

3.3.5 Expert interviews[10]

Qualitative data was collected using semi-structured interviews (Roulston and Choi, 2018) with experts in the Berg River catchment sites. Experts were selected based on their knowledge and understanding of the geographical and socioeconomic context of the Western Cape. These experts had knowledge on either parameter of the WEF nexus as well. They included municipal officials from the Local Municipality (Pniel/Lanquedoc and Velddrif) and District Municipality (Velddrif), key employers (Velddrif) and officials from sectoral provincial departments (Pniel/Lanquedoc). In the Velddrif site these were designed to complement the household questionnaire. The expert interviews sought to establish a deeper understanding of the 'supply chains' involved in supplying the WEF resources to the household level. The spatial scale of this enquiry was largely confined to the community, town and municipal scales. The purpose was to 'make visible' the water, energy and food supply chains servicing the community of Noordhoek, as well as the WEF nexus points within these supply chains. In addition, the expert interviews were used to gather information about water and energy supply and consumption balances and how these intersected with livelihoods, governance of these systems, employment opportunities and municipal local economic development plans for the area, as well as other relevant strategic plans for the area. In the upper Berg catchment sites

[10] This section is a contribution of both Penny Price and Vumande Mjanyelwa and forms part of their Masters theses.

expert interviews were employed to investigate the WEF resource availability at a regional level and to further tease out factors relating to governance of the WEF nexus that allow better access for low-income households in the two sites. See Appendix 5 for the list of experts.

3.4 Using nexus research for youth development and community empowerment

This component of the project centred around trialling a process of the inclusion of local unemployed youth in the research project. The intention was to upskill the youth and embed an understanding of WEF nexus concepts in the communities involved, as well as developing an awareness of the impacts of the nexus on their lives. A transdisciplinary approach was adopted which fostered knowledge exchange, co-production, and integration through the active participation of the local youth in the academic research project as illustrated in Fig. 5. This shows the coming together of the academic and non-academic knowledge spheres through the research process. Of significance is that the unemployed youth engaged to participate in the research through data collection were from the research sites. These youth therefore possessed local knowledge that was valuable to the researchers. Examples included access to the community members, translation when languages were a communication barrier, knowledge of local culture and norms, broad knowledge of local WEF resource consumption and supply patterns, and more. The academics had in-depth content knowledge which was shared with the youth through training and contact. An additional benefit to the youth was that they were paid a stipend linked to successful data collection. This engagement resulted in knowledge co-production, which was the pivot point of the engagement between the academic and non-academic groups in the illustration in Fig. 5. This youth and community empowerment component of the project was managed by the youth coordinator – a dedicated part time project portfolio.

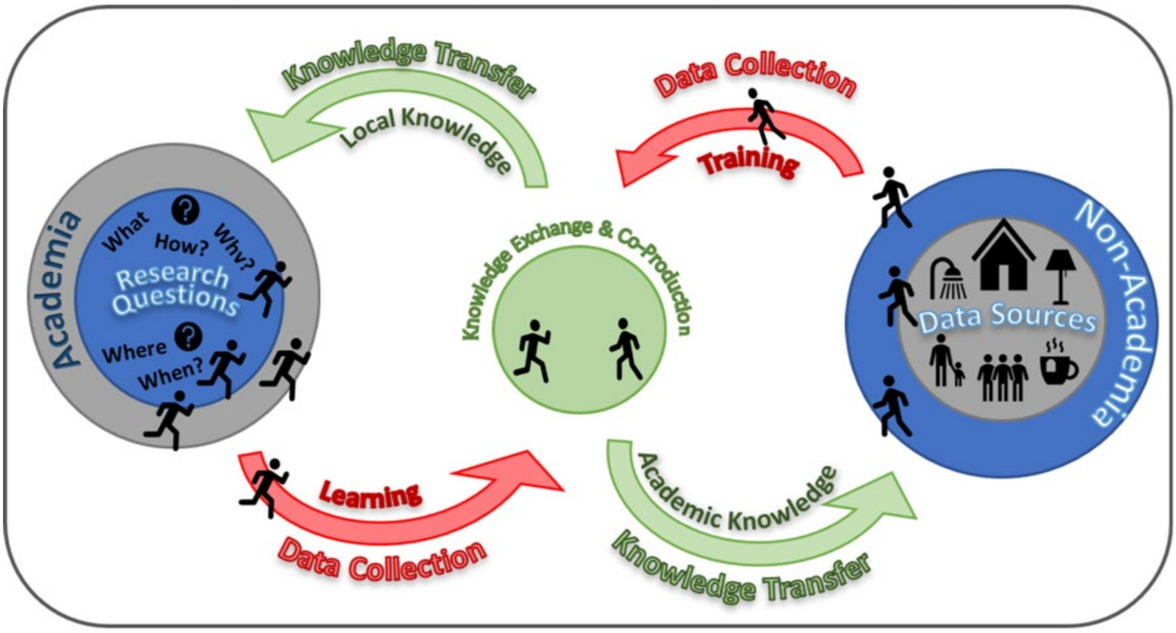


Figure 5 Diagram illustrating how knowledge co-production formed a central pivot around which local unemployed youth and academic researchers interacted through data collection and knowledge transfer characteristic of a transdisciplinary approach.

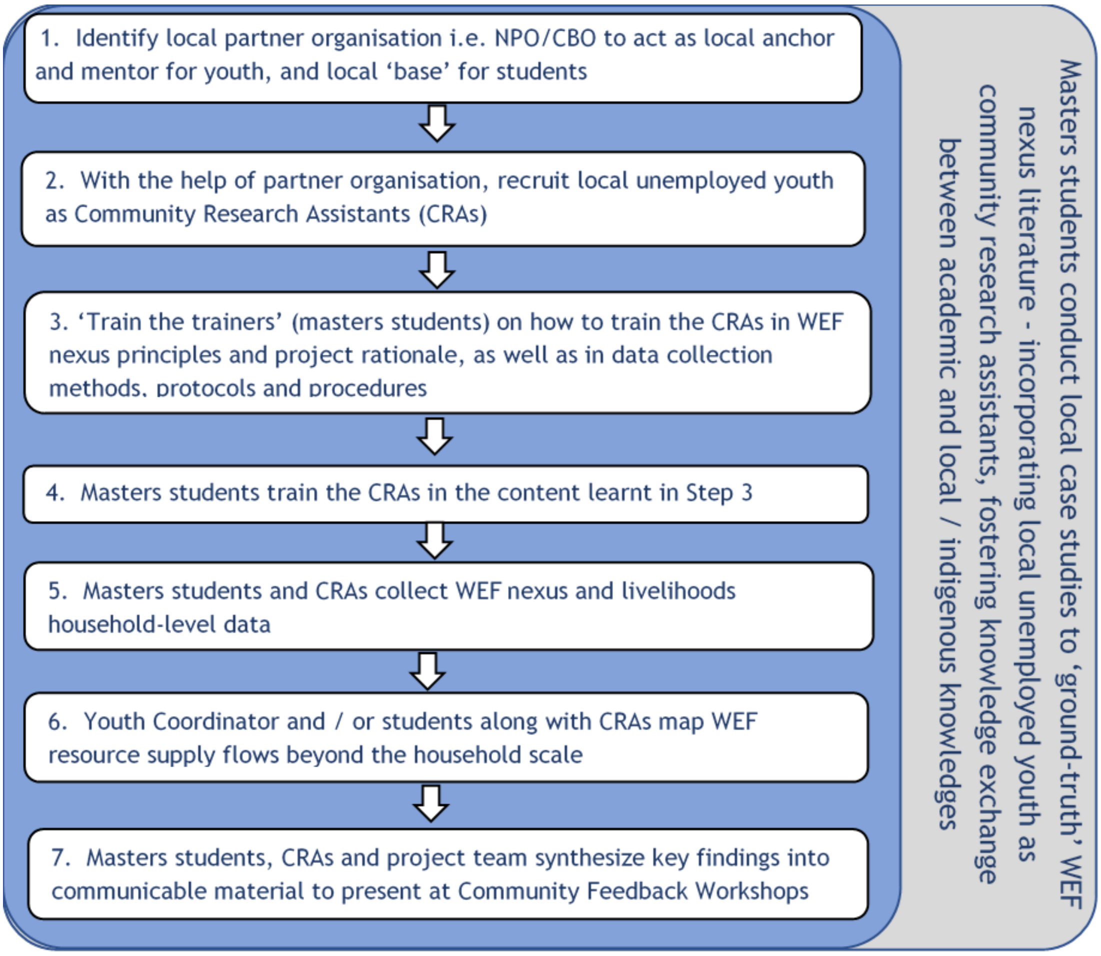


Figure 6 Step-wise design framework for incorporating unemployed youth into the study.

A stepwise framework, illustrated in Fig. 6, was designed to operationalise this approach. This consisted of seven activity steps comprising an engagement and learning process which is detailed below.

3.4.1 Identify local partner organisation

Partner organisations were identified at each research site to provide access to youth in the area and co-manage the youth during times when the student or the project youth coordinator was not present. The initial step in identifying the partner organisations included a review of existing not for profit organisations (NPOs) and other relevant organisations that had a presence in the research sites and that preferably worked with youth. This was done through the academic institutions responsible for the respective catchment studies. Suggestions put forward were followed up by the youth coordinator and the selection was finalised by the project team based on the considerations presented in Table 11. Factors considered when making these selections varied due to the diverse nature of the organisations and their mandates as well as differences in intra- and inter-catchment contexts. Arrangements with the local partners were formalised by the drawing up of a Memorandum of Understanding (MoU) between the academic institution and the partner organisation where possible. An example MoU is included in Appendix 6.

Table 11: Summary of motivation for partner organisation selection.

<table>
<tr><th>Research site</th><th>Nature of partner organisation</th><th>Motivation for selection</th></tr>
<tr><td>Pniel / Lanquedoc</td><td>A community development trust which represented the interests of several small towns in the area in terms of a land restitution claim.</td><td>• No other relevant NPO / Community-based Organisation (CBO) found to be working in the area, besides an informal youth group affiliated to one of the main churches in the area. The church did not however take up the offer of a partnership citing limited capacity to do so.
• They had community representation in both the research sites (Pniel and Lanquedoc).
• Community trust centre located between Pniel and Lanquedoc that could act as a venue when conducting training and data collection.</td></tr>
<tr><td>Velddrif (Noordhoek)</td><td>A youth facility initiative of the Provincial Social Development Department which is run by an NPO.</td><td>• Ward Councillor for the study site suggested the facility as the ideal partner in the area.
• The facility offers local unemployed youth internships, training and capacity building opportunities.
• Facility situated within the research site of Noordhoek (within Velddrif).</td></tr>
<tr><td>Hamburg</td><td>A community development trust consisting of four main project areas, namely a health project, art project, music academy, and an education centre.</td><td>• University of Fort Hare motivated for the choice based on experience of working with the trust previously.
• A well-established and well known 15-year old community development trust.
• Although there was no dedicated youth programme, the trust put forward three community health workers with extensive experience in home visits and household level surveys to act as mentors for the youth.
• The education centre was put forward as the project interface with the trust.
• The trust is centred in the research site (Hamburg).</td></tr>
<tr><td>Melani</td><td>Local traditional and ward leadership</td><td>• University of Fort Hare motivated for the choice based on extensive experience of working in the area.
• There was an absence of formal youth groups or relevant NPOs in the area.</td></tr>
<tr><td>Mpophomeni</td><td rowspan="2">A river conservation trust</td><td rowspan="2">• University of KwaZulu-Natal motivated for the choice based on experience of working with them.
• A well-established conservation trust that has been working in the area for several years and is therefore aware of the local context, sensitivities, and cultural norms.
• The trust had an existing team of ‘Enviro Champs’ in Mpophomeni made up of local youth who monitored river health in the area, noting pollution sources and driving local awareness programmes through direct household engagement that had included household water audits.</td></tr>
<tr><td>Sobantu</td></tr>
</table>

Research site	Nature of partner organisation	Motivation for selection
		• The trust also had a new River Rehabilitation team in Sobantu similar to the 'Enviro Champs' in Mpophomeni. • Located in and focussed on the upper uMngeni catchment area.

3.4.2 Recruit local unemployed youth as CRAs

The original intention was to recruit only one youth per project site. However, this was not received favourably by most project partner organisations, citing the enormous need within the youth in their communities. The number of youth engaged at each site was therefore expanded based on discussions with the partner organisation, the student, and the project lead. Once this was established, groups of youth were recruited in conjunction with the partner organisation. As shown in Table 12 this involved advertising locally for youth participation, except in the uMngeni catchment. The project team drafted an advertisement which was sent to the partner organisations to distribute in the communities. A copy of the advertisement is included as Appendix 7. Applicants submitted applications to the partner organisations. These were collected by the project team directly or the CBO and then scanned and sent to the project team. Once reviewed, the applicants that met the requirements were invited for an interview which took place at the research site. These were conducted by the youth coordinator and a representative of the partner organisation using a standard set of interview questions which is included as Appendix 8. The numbers of youth recruited as CRAs is reflected per research site in Table 12. These numbers include the replacement of youth in the event of them leaving the group of CRAs, e.g. if they secured employment.

Recruitment in the case of the two sites in the uMngeni catchment did not occur through advertisement, but differed as both sites had teams of unemployed youth already *in situ* doing stipend work which aligned strongly to the project content. In this case, the project and expected tasks were explained to the conservation trust's teams who were given the option of participating in the WEF project work. In both teams, a large proportion of the youth wanted to be involved, thus the large numbers of recruits in this catchment. However, due to the strong alignment between the research content and the work the teams were already doing, these teams were already partly trained in similar content and skills.

Table 12 Nature of partner organisation and recruitment in each research site.

	Nature of Partner Organisation	Recruitment Method	Number of youth
Pniel / Lanquedoc	A community development trust which represented the interests of several small towns in the area in terms of a land restitution claim.	Printed advertisements placed in key places across the site. Applications handed to partner organisation who handed them to project team. Youth coordinator and a representative from the partner organisation interviewed the candidates.	4
Velddrif (Noordhoek)	A youth facility initiative of the Provincial Social Development Department which is run by an NPO.	Printed advertisements placed in key places across the site. Applications handed to partner organisation who handed them to project team. Youth coordinator and a representative from the partner organisation interviewed the candidates.	7 Initially recruited 4, with additional 3 later in project following loss of 2
Hamburg	A community development trust consisting of four main project areas, namely a health project, art project, music academy, and an education centre.	Printed advertisements placed in key places across the site. Applications handed to partner organisation who handed them to project team. Youth coordinator and a representative from the partner organisation interviewed the candidates.	5
Melani	Local traditional and ward leadership	All recruitment arrangements were made directly by the University of Fort Hare team.	6
Mpophomeni	A river conservation trust	Recruitment done through the river conservation trust, who put the two teams forward. The team members were given the option of participating.	10
Sobantu			7

3.4.3 Youth workshops / 'Train the Trainer'

Due to the expanded number of youth recruited, there was a need to alter the three planned youth workshops wherein the six youth would be brought together and trained. Instead, a 'train the trainer' approach was adopted whereby the students were trained to train the youth at their respective research sites. Despite budget constraints, the first and arguably most important 'train the trainer' workshop included non-academic representation from most of the research sites, either in the form of youth team leaders or community representatives, as well as academic interns and academic supervisors who would be working with the student in the research case studies (Appendix 9). The purpose of this first training event was to provide training to the students and youth leadership where relevant, as well as other supporting academic and non-academic actors, such as interns and community representatives. The content focus of this workshop was an introduction to the WEF nexus and training on administering the household questionnaire.

Bespoke training material was developed for this event by the youth coordinator and is included as Appendix 10. This is a rich resource which covers:

- Introduction to the project and the national context within which it took place in terms of the role of the funder and why the household level WEF nexus and livelihoods are a research concern
- Introduction to key concepts including resources, WEF nexus, livelihoods and catchments
- Data collection protocols and safety
- Understanding and using the Household WEF Questionnaire

The second ‘train the trainer’ workshop included the students conducting the research at the case study sites and some of the project team members. Thus, it did not include any non-academic actors, largely due to budget constraints. This event focussed on providing training for data collection using the household audit method. The following was included:

- General approach and guidelines for the youth and community component which included:
    - Guidelines for managing the youth teams
    - Managing the field work and youth stipend budgets
- Household resource audit content training including how to conduct household energy and water audits, which included useful concepts, tables, references and templates.

Material developed for this workshop is included as Appendix 11.

The third and final ‘train the trainer’ workshop was also limited to participation by the students conducting the case study research and focussed on providing training for data collection using the resource mapping methods. Training material for this included drawing on a report of two pilot cases conducted in two of the research sites by the youth coordinator. The method varied slightly in both sites, largely based on access to the sites by the youth coordinator. This material also included assignments given to the CRAs. This method will be detailed under section 3.4.6 which deals with this activity.

3.4.4 Training local youth as Community Research Assistants

Following the ‘train the trainer’ workshop 1, and once the students were ready to start their data collection at the research sites, the students ran training with their teams of recruited youth to upskill them to CRAs. This training process was managed by the students, supported by academics from their respective academic institutions, as well as community representatives that had attended the first ‘train the trainer’ workshop. Once this was completed, the students and the CRAs started collecting household level WEF and livelihoods data.

3.4.5 Masters students and CRAs collect WEF nexus and livelihoods data

In the Berg and Keiskamma catchments the primary data collection method was the household questionnaire. These were administered by the students and the team of CRAs. These teams were often bolstered by academic interns or other post graduate students willing to assist. The participation of other academics was encouraged in order to aim for data collection pairs that consisted of one academic and one non-academic. This was found to be an optimal configuration as it combined the CRAs’ local knowledge and access to the community with a deeper understanding of the research process, ethics, content and protocols used for academic inquiry. However, where this was not possible, CRAs paired up as the data was always collected in pairs, both as a safety measure and to ensure that the data was correctly captured. In the uMngeni catchment the household questionnaire method was replaced with the guided conversations method. This change in method required that the student needed to conduct each 'conversation', and the CRAs could therefore not play as much of an active data collection role as they did in the other sites. They were, however, divided into teams and did accompany the student on a rotational basis, assisting with access to the community, introducing the student and the research to the community members and related support tasks.

A second source of household level data collection in which it was planned that the youth would be involved was the household WEF resource audit. One of the reasons for involving the youth in the data collection was to upskill them in ways of monitoring use and consumption patterns of the three resources, learn how and when at least two of the three resources interact and to initiate a discussion around opportunities on how their communities could manage the three resources more efficiently at household level. Similar to the training for the household questionnaire, the students received training in the proposed method, with a view to training the CRAs. However, as highlighted in section 3.2.2 the method in the context of this project turned out to be an inadequate learning and household data collection tool. The key challenges that were highlighted in section 3.2.2 relate to safety of youth, trust of the community and quality of the data obtained. To address all three challenges would have required more resources and time, including already involving the youth and communities in the design phase of the project (e.g. proposal development).

3.4.6 Masters students and CRAs map community-level resource flows

The resource mapping (Table 13) was done using a combination of participatory mapping techniques, site visits to key WEF resource related infrastructure, and interviews with key actors in the local WEF resource supply chains.

A more in-depth resource mapping was conducted at two of the research sites, one in the Berg catchment and one in the Keiskamma catchment, compared to the other sites. This was due to the youth coordinator being present at both sites for extended periods, enabling an emergent process to unfold in response to exploratory enquiry around the 'making visible' of the WEF resource supply chain beyond the household. Due to a difference in entry point and student disciplinary enquiry, the processes in these two sites differed slightly. At the Berg site, resource mapping commenced once the household survey had been completed. The entry point here was through the engagement of municipal officials in the water and electricity departments through expert semi-structured interviews, and subsequent field visits to water and electricity supply and waste (in the case of water) infrastructure from the household level to the edge of the town. These activities included the CRAs. The field visit sites were captured using GPS and located on a map. As there is a high reliance on retail as a source of food, the retail environment including local community corner shops (spaza shops) was mapped using GPS and included on the same map, thus obtaining a map of the WEF supply systems for the area.

Table 13 Resource mapping methods, scale and system definition per site.

	Velddrif	Hamburg	Sobantu & Mpophomeni
Water	Bulk water supply mapped to the district municipality scale through guided site visits, expert interviews and literature sources. Wastewater system at the town scale mapped through guided site visit and expert interview.	Bulk water supply mapped to the Bulk Water Supply Provider (Water Board) through participatory mapping, guided site visits and expert interviews. Some alternative water sources like rainwater tanks mapped during food system mapping (photovoice).	Bulk water supply mapped to the catchment scale through participatory mapping, expert interviews and literature sources. Wastewater system mapped at a town scale (Pietermaritzburg) through guided site visit.
Energy	Bulk electricity supply system mapped at a town scale through expert interview and guided site visits.	Energy sources mapped at a town level through participatory mapping.	Electricity supply system mapped at a town scale through participatory mapping.
Food	Large retail as well as local spaza shops mapped at a town level through participatory mapping and expert interview. Fish factory and mussel processing plant mapped at a town scale through participatory mapping and expert interview.	Local small-scale farmers and related infrastructure mapped at a town scale through participatory mapping and photovoice. Local shops through participatory mapping. Aquaculture facilities through participatory mapping and literature sources.	Food system mapped at a town scale through participatory mapping.

At the Keiskamma catchment research site, the entry point was the youth who had been recruited. At that point, the student was not yet cleared to commence field work. The youth coordinator therefore started the data collection by conducting the resource mapping in the area. As this was the initial engagement between the project team and the recruited youth, the exercise started with the training module 1, which included introduction to the project and WEF nexus and related concepts. This was followed by participatory mapping whereby the group started by mapping the individual WEF resources, then combining them into a WEF nexus map. The group included four additional youth from the Wildlife and Environment Society South Africa (WESSA) Beach Stewardship team who volunteered to participate. This map drawing exercise took place over two days and was occasionally embellished with inputs from local villagers passing by or by consultation with local experts. Following this the group of three youth and the community trust representative travelled to offices of the area Water Board where they met with an expert who explained the following related to water supply in their area:

- Mandates
- Financial flows / business model
- Infrastructure including ecological infrastructure and the concept of the ecological reserve
- Management and maintenance
- Spatial geography

In parallel to this visit, two CRAs conducted a 'photovoice'-styled exercise of some of the key food producers in the area. This involved visiting some of the major food producers in the area that had been identified during the participatory mapping exercise. They were interviewed and photographed with their produce/stock. This was followed by a group field visit accompanied by an official from the District Municipality to relevant water infrastructure that serves the town. The final stage was the incorporation of the information from the visit to the Water Board, the field visit and any new information gathered through the 'photovoice'-styled exercise to be included on the original drawn WEF nexus map. A digitisation exercise was done in a follow up visit where the mapped points were transferred onto a digital map and additional points were identified through a drive around the site with the youth. An assignment was given for the following week relating to this trip and the photovoice exercise.

Resource mapping also took place at both sites in the uMngeni catchment. This replicated the participatory mapping exercise at the Keiskamma site. However, it was done over the course of a morning, not a few days, and was done with the groups from both sites together, with each working on their own maps. This was followed by a talk given by a representative from the local Water Board who presented the mandate, infrastructure, management and maintenance and spatial geography associated with water supply in the area. This was followed by a field visit to the wastewater treatment site next to one of the research sites.

3.4.7 Masters students, CRAs and project team present findings to the community

The final step included the synthesis of the data collected and the feeding back of this information to the community(ies) at the research sites. The method envisaged included the youth in 'translating' the research findings into accessible language and formats to co-present back to the community. Workshops were held in which the preliminary findings were presented back to the communities by the students accompanied by other academic project participants. In some of the sites the youth attended the workshops but did not play a role in the synthesis or presentation of the data to the communities.

Outputs generated through the stepwise approach contributed towards both the achievement of the case study research undertaken by the students through data collection as well as the project aim of involving and upskilling local youth and community empowerment. Additional methods utilised outside of the stepwise framework included personal development training workshops for the youth on the development of a curriculum vitae, job application and interview skills.

CHAPTER 4: RESULTS FROM CASE STUDIES – THE QUANTITATIVE LENS

4.1 Level 1: What the Census tells us

The last Census conducted in 2011 still provides a valuable picture of the socio-economic context at household level of each study site. The strength of using Census data to supplement our primary data lies in the fact that the entire population is captured, rather than a sample. This will allow us, in the following chapters, to compare the sample-based results of this study for the different sites with the overall population.

The settlements of Pniel, Lanquedoc, Noordhoek and Sobantu have population sizes ranging between ca. 2000 and 7500 (Fig. 7). The two settlements in the Keiskamma Catchment (Melani, Hamburg) have a lower population size (<1350 persons) and Mpophomeni in the uMngeni Catchment, as defined by the Census sub-place boundaries, has a large population size (25732 in 2011). Pniel, Lanquedoc, Mpophomeni and Sobantu are relatively densely populated compared to Noordhoek, Melani and Hamburg (Fig. 7).

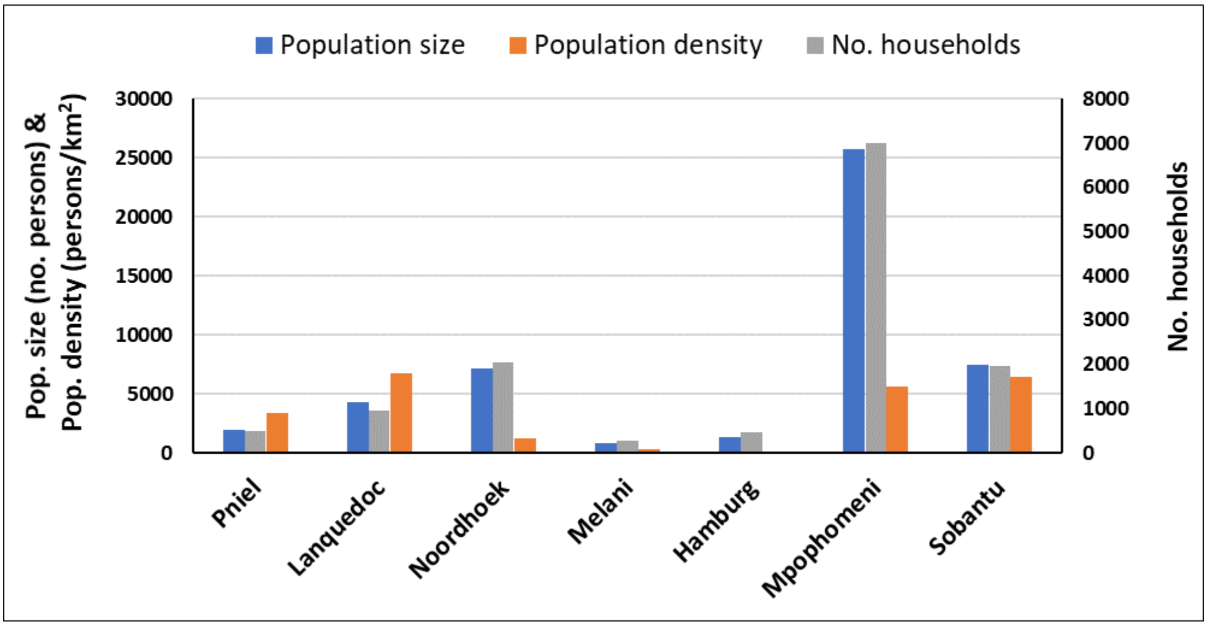


Figure 7 Population size, population density and number of households at each study site based on the South Africa Census 2011.

In all settlements, most households have 2-4 members and 89% or more of households have seven or fewer members (Fig. 8). Larger households of eight or more members make up 4-5% of households in Sobantu and Lanquedoc. One-person households are more prevalent in the settlements of the Keiskamma and uMngeni catchments compared to the Berg catchment. Formal houses are the dominant dwelling type, but in Lanquedoc and Hamburg, 12.5% and 20.2% of dwellings, respectively, are informal (Fig. 9). In the uMngeni, 46-49% of households are male-headed, in the Keiskamma this figure is 51-56%, and in the Berg it is 58-78% with Pniel having the highest percentage. The differences between settlements in age structure of households are smaller, with 62-72% of members being of working age (15-64 years) in all the settlements (Fig. 9). The young (0-14 years) are 27-30% of household members, except for Sobantu (24%) and Pniel (19%) (data not shown). A higher percentage of the elderly (9-12%) are found in Pniel, Hamburg and Melani compared to the other four settlements (3-5%) (data not shown).

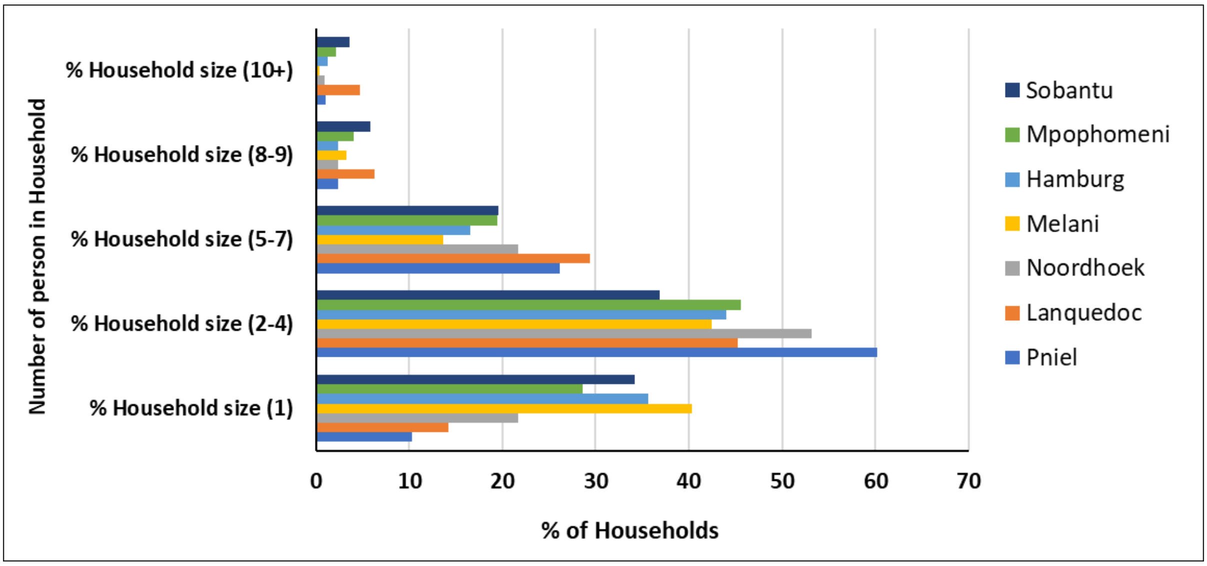


Figure 8 Households size (number of members) at each study site based on the South Africa Census 2011.

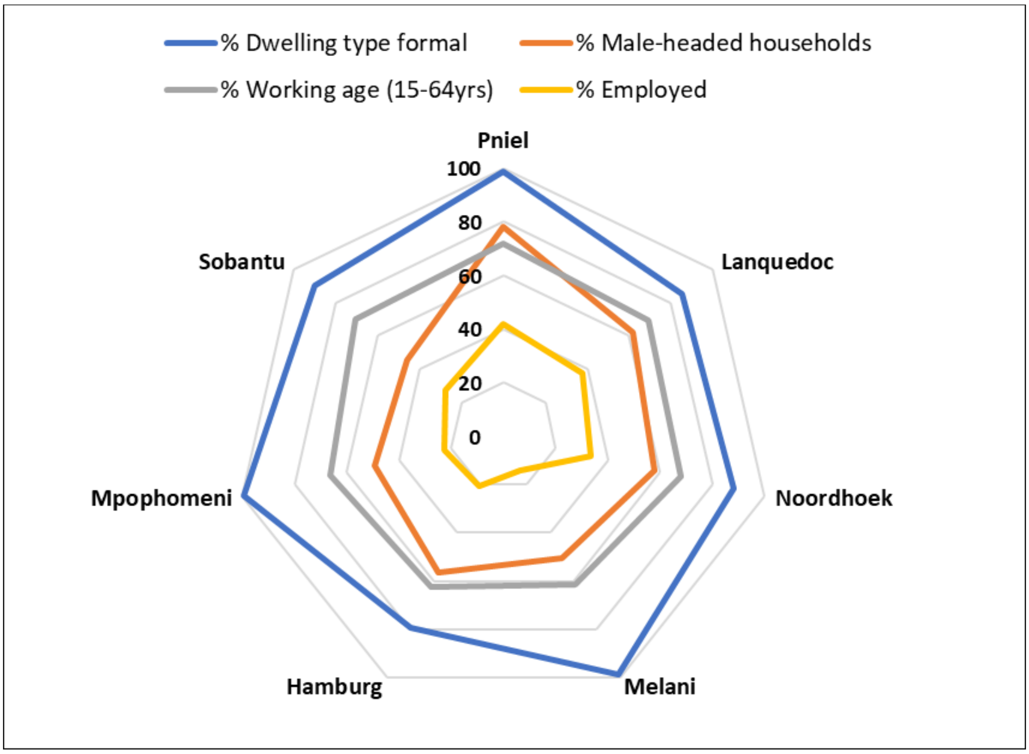


Figure 9 Percentage dwelling type (formal), male-headed household, head employed, and working age people (15-64 yrs) at each study site based on the South Africa Census 2011.

Employment figures are higher in the Berg (33-42%) compared to the uMngeni (22-28%) and the Keiskamma (14-21%) (Fig. 9). This links to the range of incomes found between households (Fig. 10). In Pniel, about 34% of households have an annual income of more than

R153 801, with the next highest being Sobantu (11%), Noordhoek (8%) and Lanquedoc (5%). On the other side of the spectrum, 60% (Hamburg) and 69% (Melani) in Keiskamma, 53% (Mpophomeni) and 39% (Sobantu) in uMngeni, and 43% (Noordhoek, Berg) of households earned less than R19 600 per annum in 2011. In Pniel and Lanquedoc, this figure is 23% and 26%, respectively. Within the Berg, Noordhoek is clearly poorer than Pniel and Lanquedoc but does have a few wealthier households. Households in the Keiskamma are poorer across the board, with Hamburg having a section of the population that is better off. Sobantu has fewer very poor and more wealthier households compared to Mpophomeni. Across the three catchments, Sobantu and Noordhoek have similar income profiles, and Mpophomeni and Hamburg are similar. Overall, households in the Berg are in the best employment and income position, those in the uMngeni are intermediate, and those in the Keiskamma are worst off.

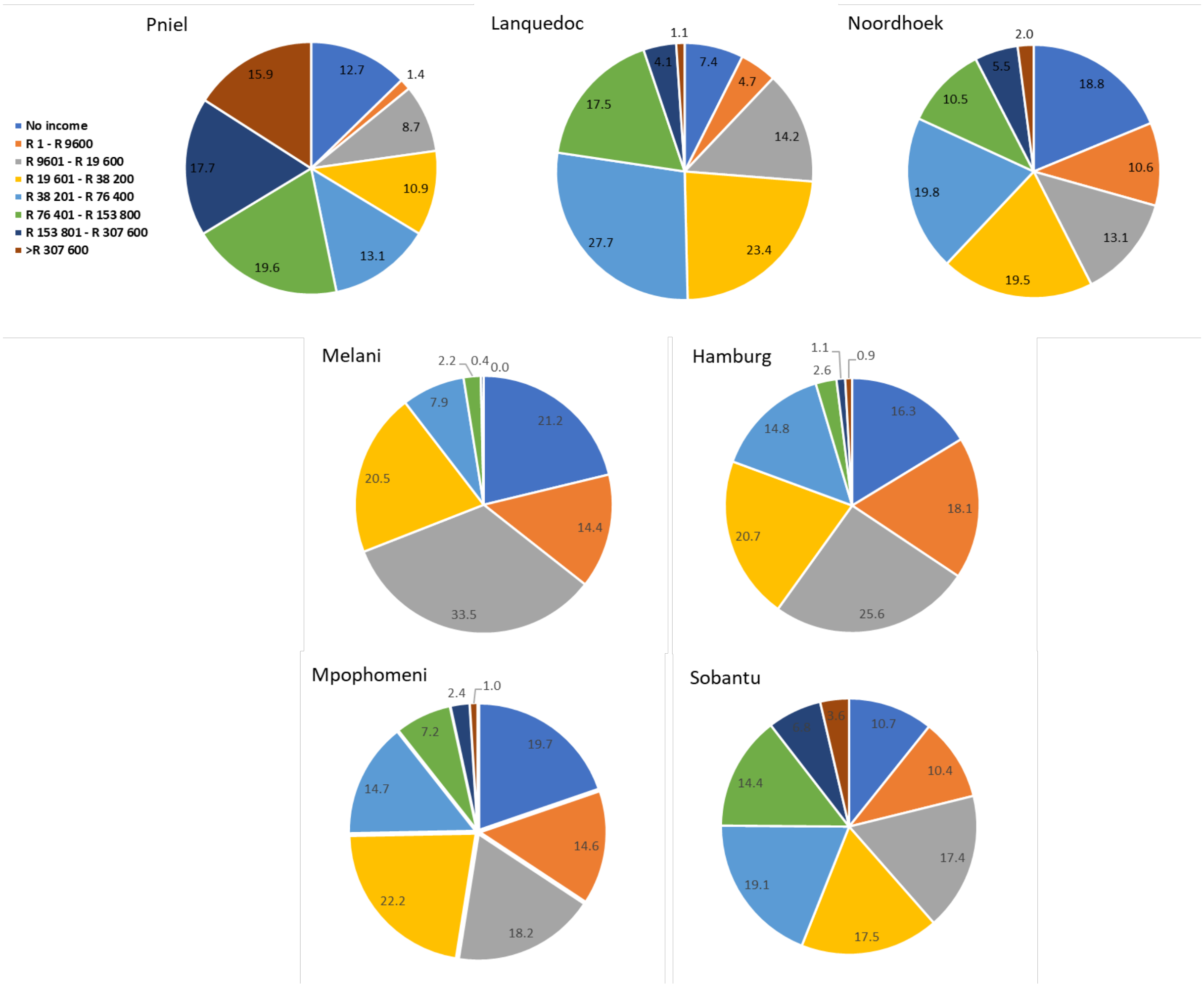


Figure 10 Income profile (percentage of households in various income categories) at each study site based on the South Africa Census 2011.

The level of schooling also varies between settlements and between catchments (Fig. 11). Similar to income, Pniel has the highest percentage of people with more advanced education (matric and higher) compared to all the other settlements. This is followed by Mpophomeni and Sobantu. Lanquedoc, Noordhoek and Hamburg have similar profiles, although Hamburg has a slightly higher proportion of people with matric or higher. The profile in Melani is the weakest of the settlements, with only 11% having matric or higher and 55% having no schooling or some primary schooling.

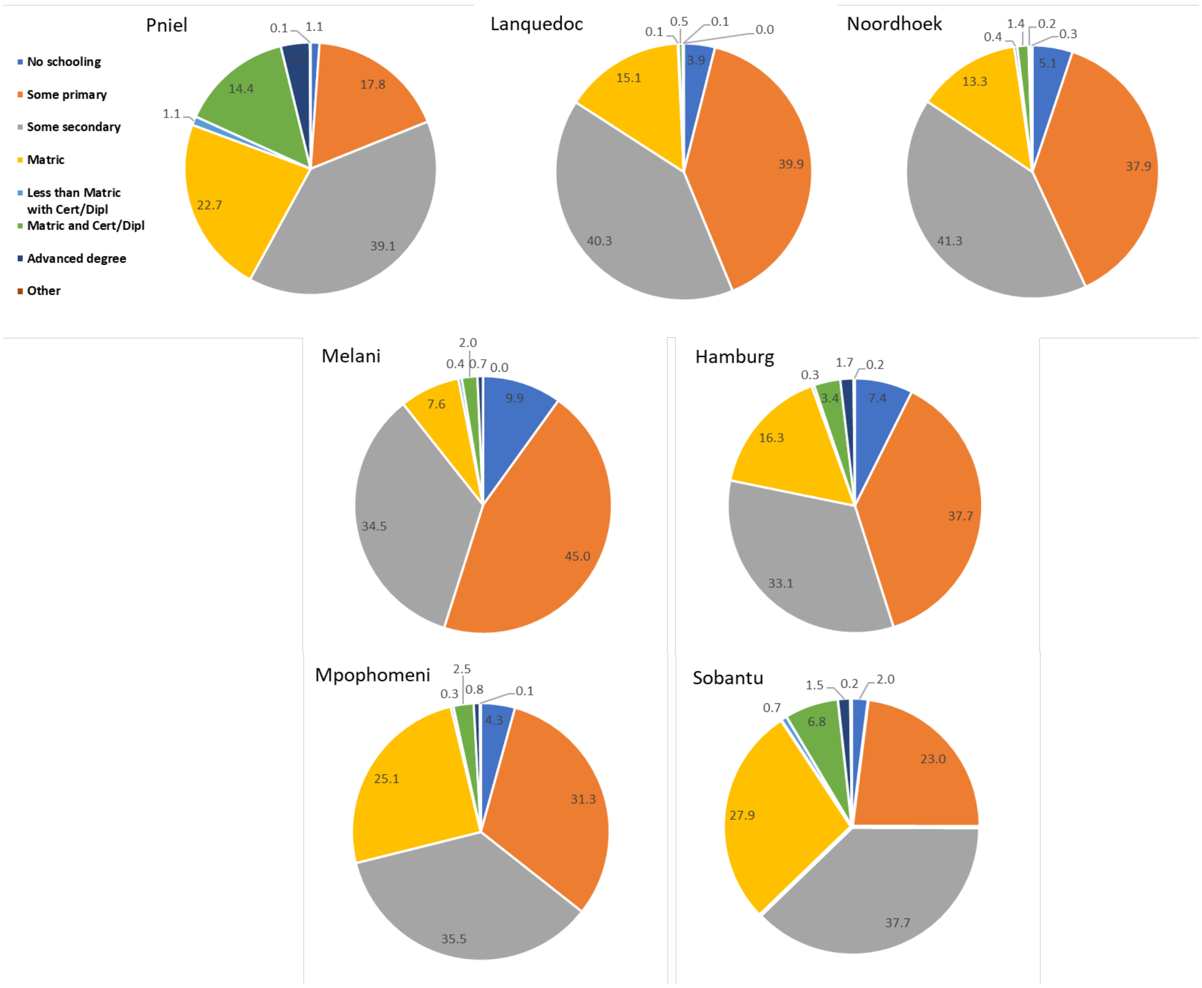


Figure 11 Educational profile (percentage of the population in various education categories) at each study site based on the South Africa Census 2011.

Fig. 12 shows in which type of sector employed household members work. While most employment is in the formal sector[11] in most settlements, Lanquedoc has a high proportion of workers in the informal sector – these are seasonal workers mainly employed on farms in the area. Hamburg also provides significant informal employment, probably linked to fishing and tourism. A high proportion of workers in Melani are employed in private households, probably in the neighbouring University town of Alice.

[11] The formal sector encompasses all jobs with normal hours and regular wages, and are recognized as income sources on which income taxes must be paid.

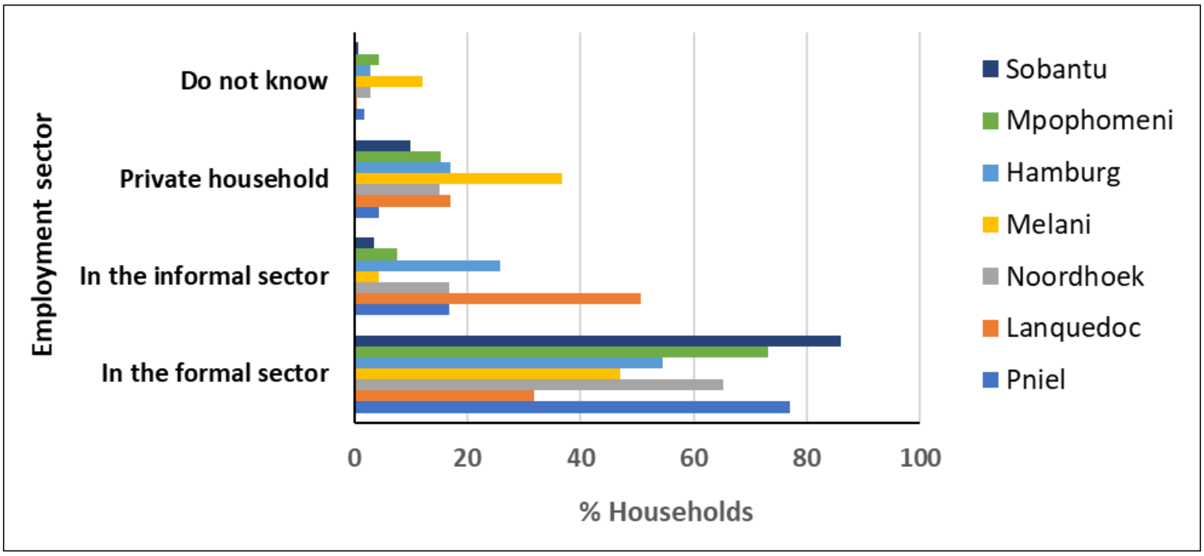


Figure 12 Percentage of working people in four different employment sectors at each study site based on the South Africa Census 2011.

The following three figures (Figs 13, 14 and 15) summarise the census data with respect to household energy source/use, water source and toilet system, and key household assets that require water and/or energy, respectively. Fig. 13 shows that Pniel, Noordhoek, Sobantu and Mpophomeni use mostly electricity for lighting, cooking (electricity and gas) and heating. Households in Lanquedoc also use wood for heating (19%) and 11% do not use energy for heating. In Noordhoek, 17% of households do not use energy for heating. Although electricity is available and used for lighting in 96% (Melani) and 88% (Hamburg) of households in the Keiskamma, less than 80% of households use electricity or gas for cooking. Only 24% (Melani) and 35% (Hamburg) use electricity for heating. A significant proportion of Hamburg households (36%) do not use energy for heating, or they use paraffin (17%). In Melani, paraffin (31%), wood (15%) or coal (13%) are also used for heating, and 16% of households do not heat.

Water is predominantly obtained from the regional or local water scheme (usually through the Municipality). Springs, rainwater tanks, dams/pools, water tankers and other sources of water are used mainly in the Keiskamma Catchment (Fig. 14). This catchment is also characterised by the lack of flush toilets, with households using pit toilets instead. It is not known to what extent these have been replaced with flush toilets by 2020. The bucket toilet system is used by 14% of households in Lanquedoc. A flush toilet with septic tank is also used to a small degree in Noordhoek and Hamburg (data not shown), and Noordhoek households also report using the bucket system (3%) or having no toilet (3.3%) or 'other' (3.9%).

A relatively high proportion of households own a refrigerator (Fig. 15), which implies that they have access to either electricity or gas to run the refrigerator. In the Berg and uMngeni Catchments the figures are greater than 75% of households, and in the Keiskamma the figures are 56% (Hamburg) and 64% (Melani). Washing machines (using water and electricity) are found predominantly in the Berg Catchment households (>50%), with much lower figures of 12-16% in the Keiskamma and uMngeni Catchments. Commensurate with income levels, 72%

of Pniel households own a car (energy source petrol or diesel), compared to 21-27% (Lanquedoc, Noordhoek, Sobantu) and 7-16% (Melani, Hamburg, Mpophomeni).

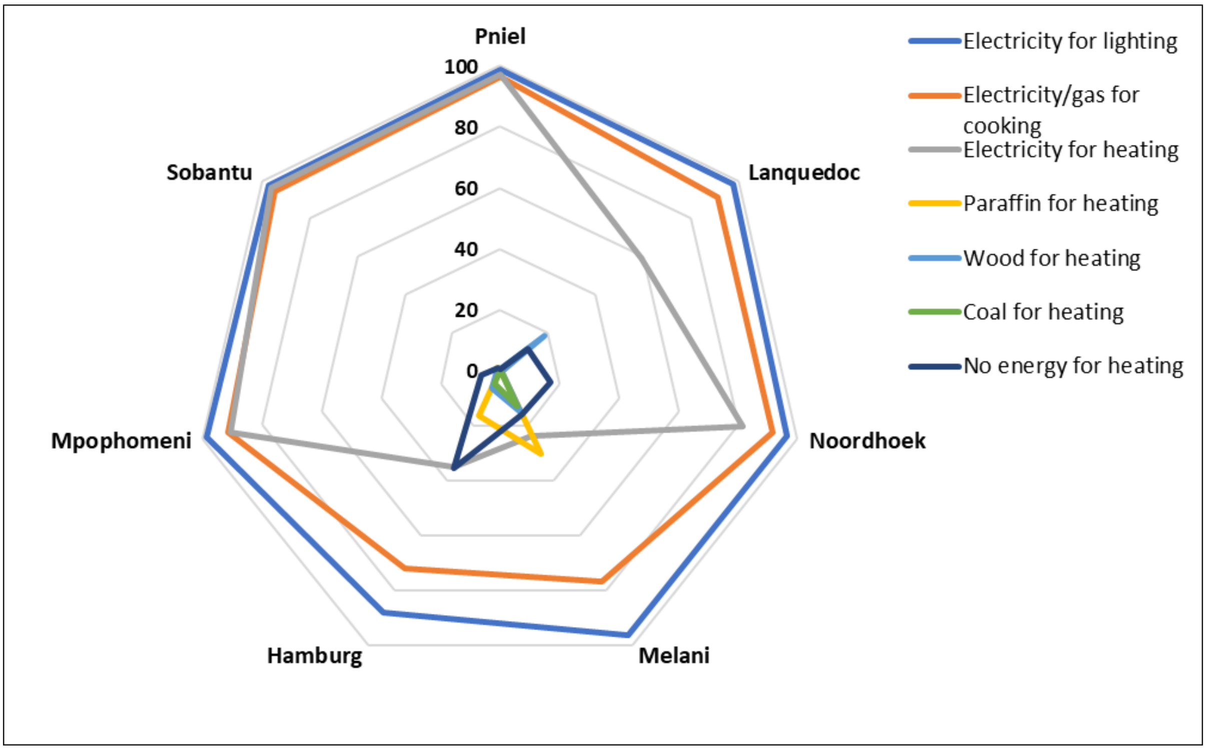


Figure 13 Percentage of households using various energy sources at each study site based on the South Africa Census 2011.

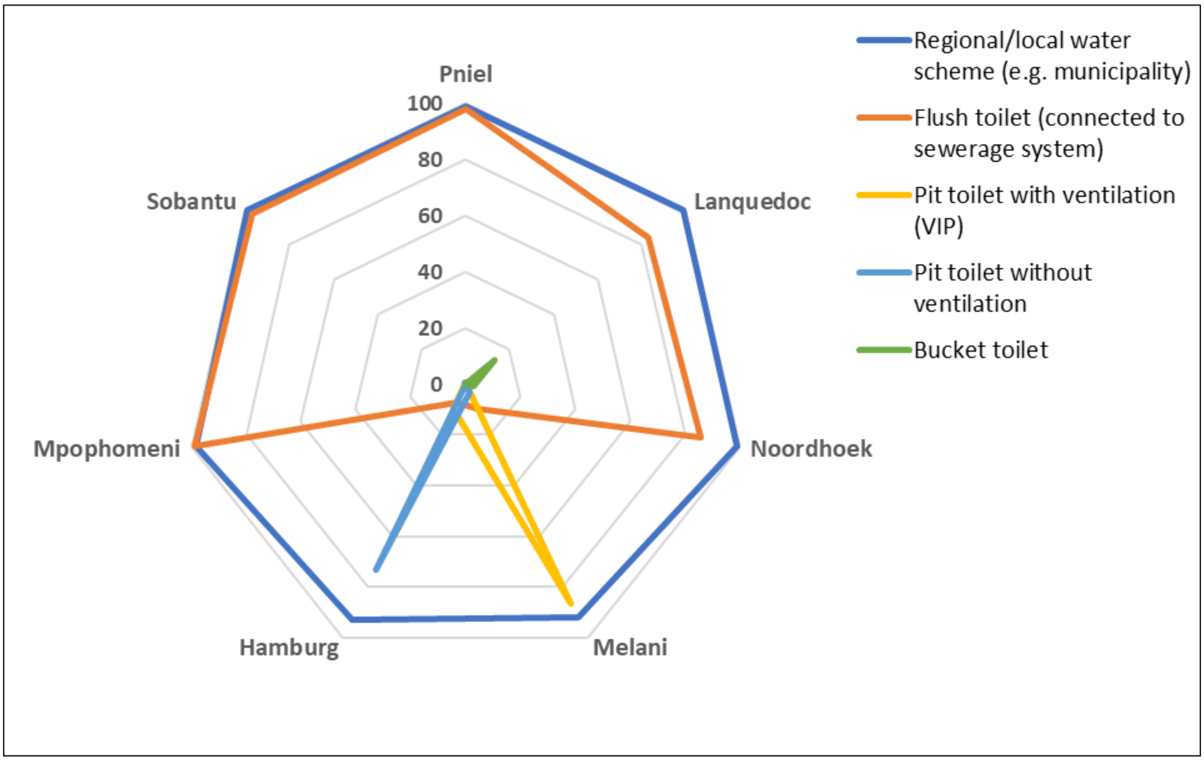


Figure 14 Percentage of households using a regional or local scheme water source, and using various types of toilet, at each study site based on the South Africa Census 2011.

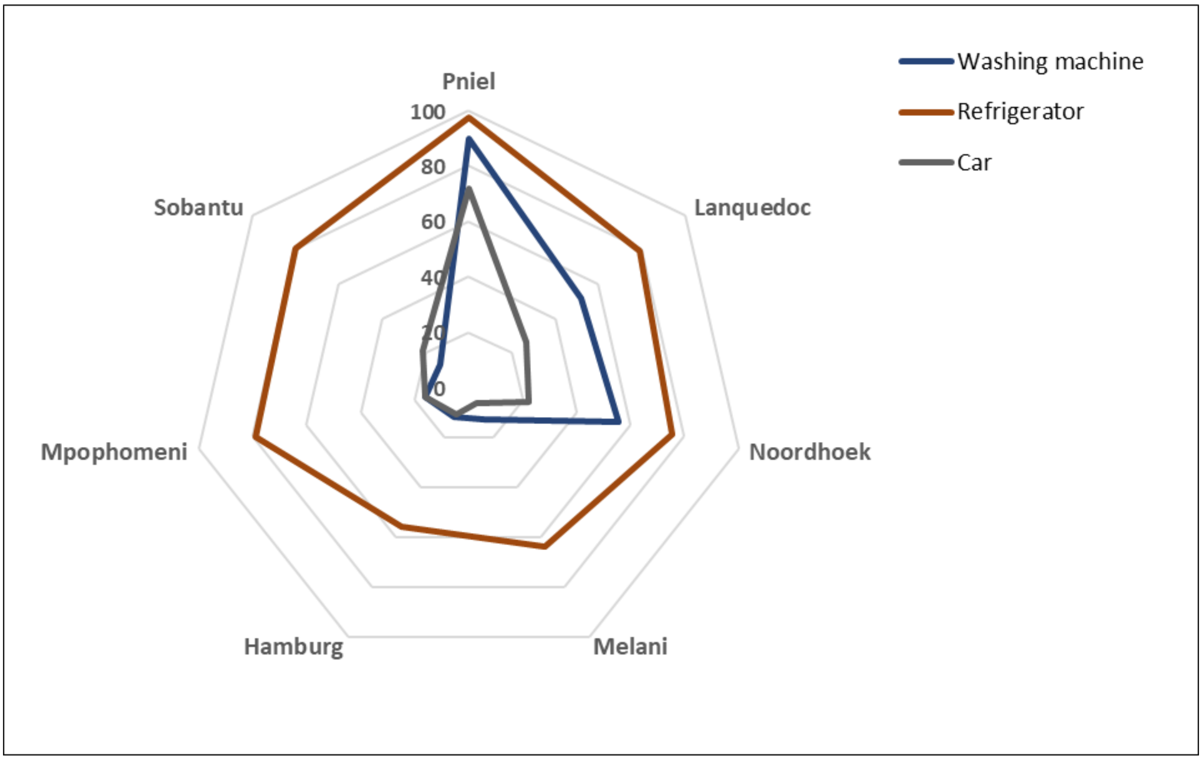


Figure 15 Percentage of households owning a washing machine, a refrigerator or a car at each study site based on the South Africa Census 2011.

Fig. 16 summarises results of the census data analysis, showing the key variables relating to household income, availability of water- and energy-related municipal services, and ownership of three household assets that require energy and/or water and have connections with food. All these variables reflect better standards of living in the case of high prevalence. Further, ownership of a refrigerator implies availability and access to electricity or gas and improves food storage thus contributing to better nutrition and reduced food waste. Ownership of an electric or gas stove implies availability and access to these energy sources and supports efficient and healthier cooking practices. Both electricity and piped water must be available and accessible to run a washing machine.

In the Berg Catchment, the above listed variables are relatively high overall (Fig. 16). Noordhoek households have a lower income but are otherwise similar to Lanquedoc households based on the variables shown in Fig. 16. Pniel households do better than Lanquedoc households in the areas of having flush toilets connected to a sewerage system, and ownership of a refrigerator or washing machine. In the Keiskamma Catchment, the two settlements are comparable, with both generally having electricity available for lighting and water from a local water scheme, but modern sanitation systems do not exist (Fig. 16). Households generally use electricity or gas to cook but poverty likely excludes ownership of a refrigerator (for around 40% of households) or a washing machine (for 88% of households) and/or the cost of running such appliances. The two settlements in the uMngeni Catchment show similar characteristics around standard of living elements, except that Mpophomeni has lower household income (Fig. 16). As for the Keiskamma, investment in a stove is prioritised by households, followed by a refrigerator and lastly a washing machine, although in almost all households, electricity and piped water are available. Affordability of appliances and of energy and water to run them is thus a limiting factor.

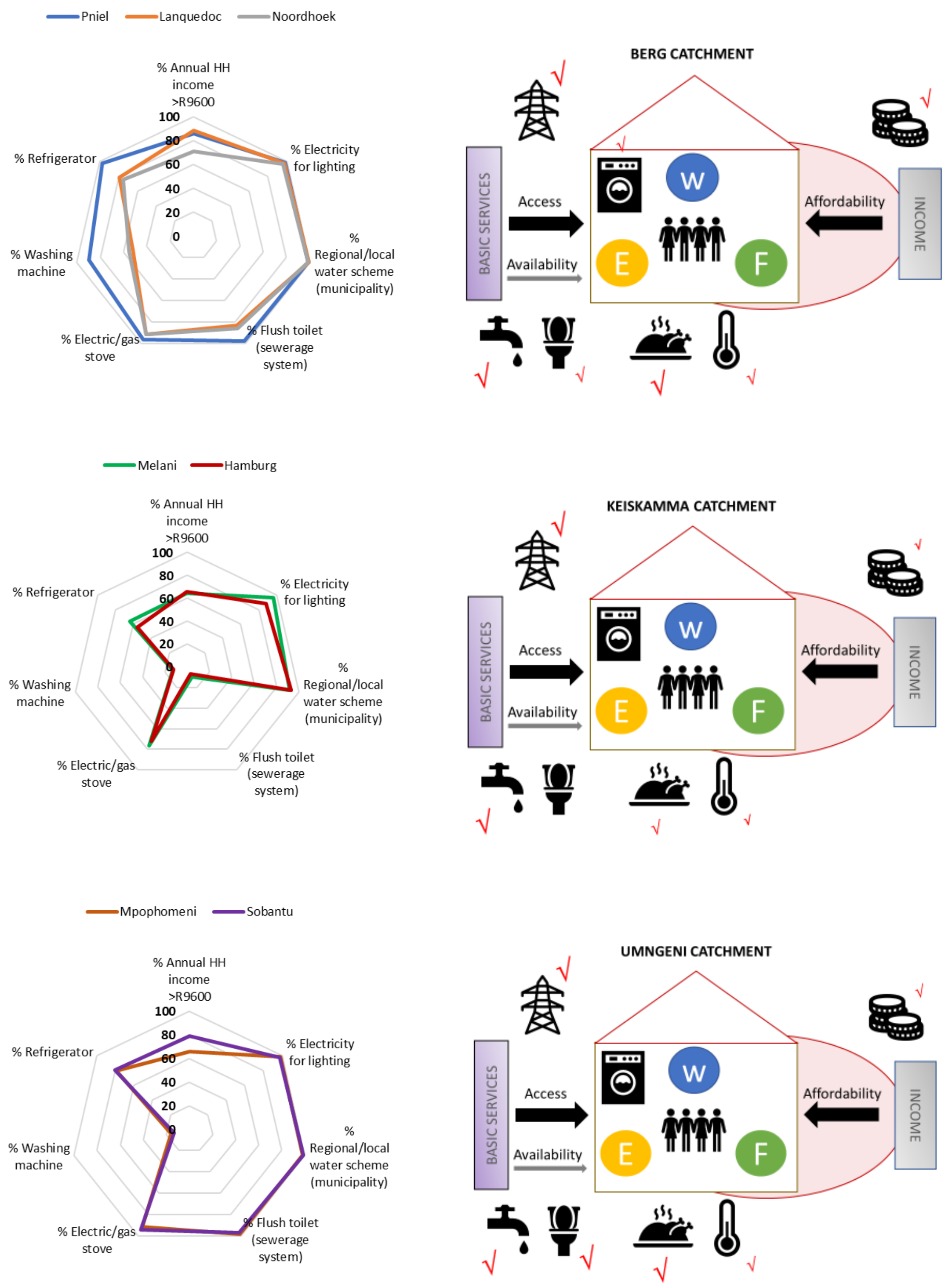


Figure 16 Summarised results of the census data analysis, showing the key variables relating to household income, availability of water- and energy-related municipal services, and ownership of three household assets that require energy and/or water and have connections with food. Symbols represent, clockwise from top left: access to grid electricity, household income, refrigerator, stove/oven, improved toilet type, water from a regional/local water scheme, washing machine. The size of the red tick symbolises the relative access; no tick denotes almost no access.

4.2 Level 2: A comparison of four communities in the Berg and uMngeni catchments

4.2.1 All variables

The MCA plot (Fig. 17) shows close correspondence between the three Berg communities, with Pniel having lower variability between households than Lanquedoc and Noordhoek. Considerable overlap is seen between the Berg communities and the Sobantu community.

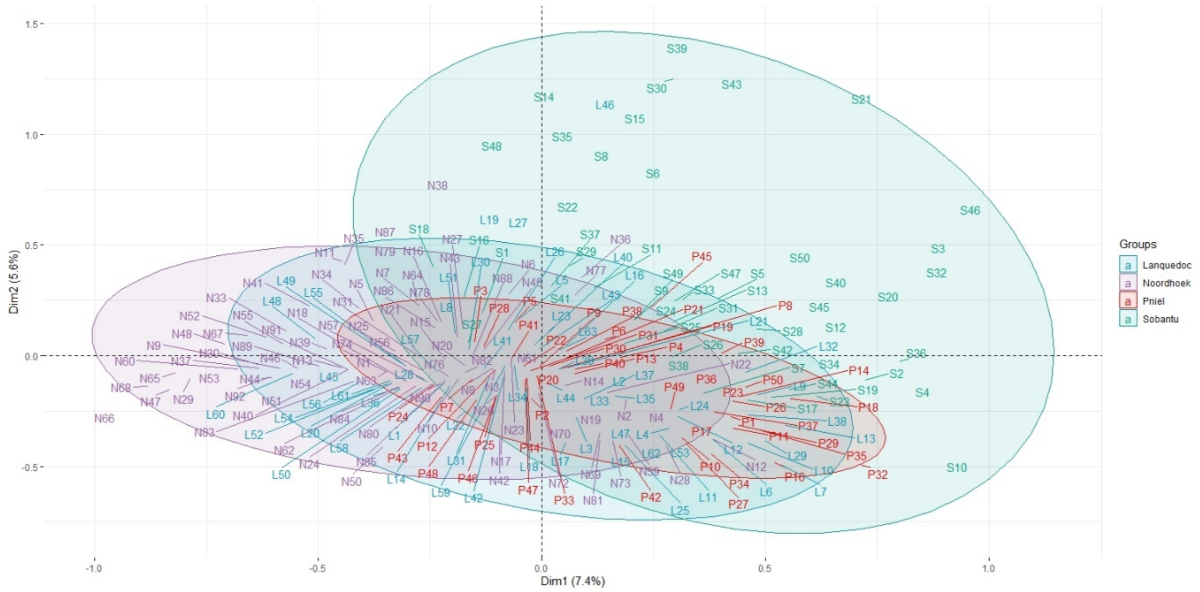


Figure 17 Multiple Correspondence Analysis (MCA) plot showing the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households), and one community in the uMngeni catchment: Sobantu (50 households) in terms of 18 variables (31 columns) relating to household level contextual information as well as water and food. The communities are colour coded and ellipses indicate the extent of variation within the community and overlap with others. Dim = dimension (with % explained variance given in parenthesis), L = Lanquedoc, N= Noordhoek, P = Pniel, S = Sobantu.

Three clusters were delineated as shown in the factor plot (Fig. 18). The significant variables (Fig. 73 in Appendix 3) were analysed and the results presented in Table 14 in decreasing order of statistical significance.

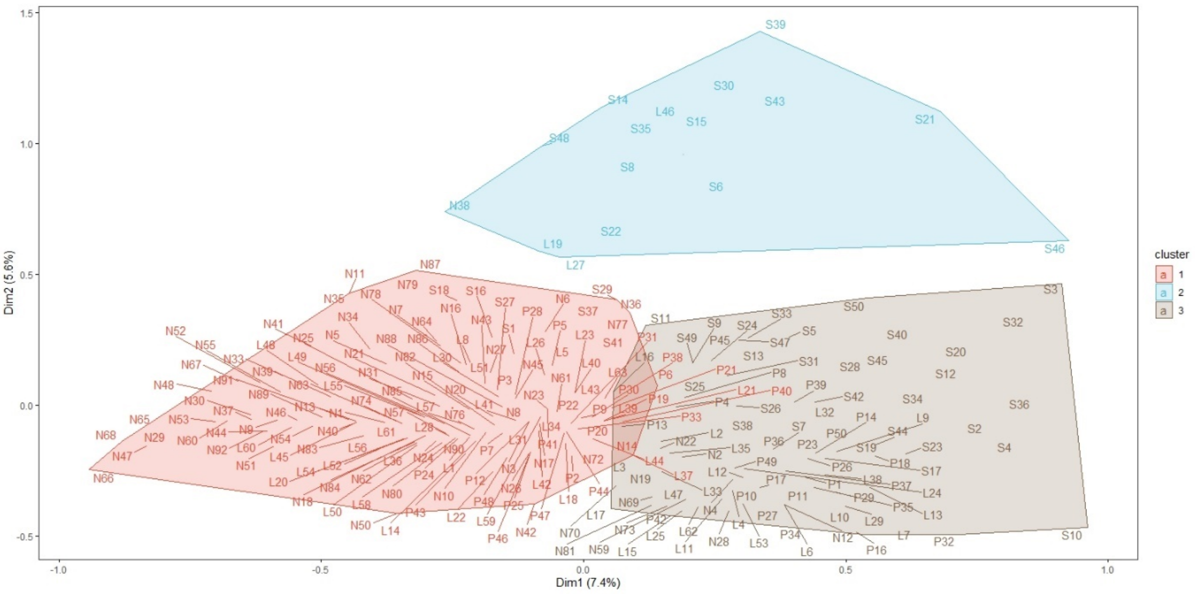


Figure 18 Factor plot visualising the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) and one community in the uMngeni catchment: Sobantu (50 households) in terms of 18 variables (31 columns) relating to household level contextual information as well as water and food. The first two dimensions are plotted (Dim 1 and 2), with a cumulative explained variance of 13.0%. Clusters of households, and their minimum bounding geometries, are coloured according to three groups which were selected using the corresponding dendrogram and each household is labelled according to its unique ID: L = Lanquedoc, N= Noordhoek, P = Pniel, S = Sobantu.

Cluster narrative (all variables)

Cluster 1 – ‘Small, working age and vulnerable to food insecurity’: This is the largest cluster, with households from all four communities, including around half of Pniel and Lanquedoc, 80% of Noordhoek and a small group of Sobantu households. A typical household has a head of working age (20-60 yrs old) and income is from wages, salary or business profit, and excluding a pension. Household size is generally 2-4 persons; one or two people contribute to household income. Employment in agriculture/forestry/fisheries is common, and often seasonal. A low number of households work in manufacturing or receive a grant. All households receive municipal services which are seen to be reliable. However, although most households access drinking water from a tap inside the house, one quarter of households use a tap outside the house. A typical household has experienced a decline in food affordability and food diversity over the last few years. While all households purchase food in formal outlets, 43% grow some foods themselves. Households generally cannot spend more than 50% of their income on food, with many spending less than 25% of income on food.

Table 14 Results of Level 2 analysis (Berg communities and Sobantu) based on variables in the categories household, water and food. H= variables relate to the household, W= variables relate to water, F = variables relate to food. For the full names of the variables, refer to Appendix 3.

Variable	Cluster 1 25/49 Pniel 37/63 Lanquedoc 75/87 Noordhoek 7/50 Sobantu Total: 144	Cluster 2 0/49 Pniel 3/63 Lanquedoc 1/87 Noordhoek 12/50 Sobantu Total: 16	Cluster 3 24/49 Pniel 23/63 Lanquedoc 11/87 Noordhoek 31/50 Sobantu Total: 89
F_FoodAfford	88% Declined	100% Improved	83% Declined
H_MajorIncSou_Pension	98% No	88% No	83% Yes
F_FoodDivers	78% Declined	94% Improved	80% Declined
H_AgeHH	44% 20-40 yrs 51% 41-60 yrs	44% 41-60 yrs 31% >60 yrs	27% 41-60 yrs 69% >60 yrs
H_MunicServ	100% Yes	100% Yes	100% Yes
F_FoodLoca_Formal	100% Yes	100% Yes	100% Yes
H_MajorIncSou_Income	96% Yes	88% Yes	57% Yes
H_NoHHContri	54% one person 38% 2 people 6% 3-4 people	81% one person 13% 2 people 6% 5 people	55% one person 10% 2 people 34% 3-5 people
F_FoodExpend	36% <25% 44% <50%	38% <50% 38% <75%	31% <50% 39% <75%
H_NoHH	63% 2-4 persons 25% 5-7 persons	31% 2-4 persons 44% 5-7 persons	39% 2-4 persons 39% 5-7 persons
H_EmplSect_AgricForFish	38% Yes	31% Yes	92% No
F_FoodLoca_OwnGarden	99% No	88% No	83% No
H_EmplSect_Manufacturing	89% No	44% Yes	92% No
H_MajorIncSou_Bursary	100% No	12% Yes	98% No
H_MajorIncSou_Grant	14% Yes	50% Yes	17% Yes
H_EmplType_Seasonal	26% Yes	94% No	92% No
F_GrowFood	57% No	69% No	64% Yes
W_MajorDrinkWatSou	69% Tap in house 24% Tap outside	88% Tap in house 12% Tap outside	96% Tap in house
H_EmplSect_Other	15% Yes (Noordhoek)	100% No	97% No
H_MunicServRel	90% Yes	69% Yes	79% Yes
H_EmplType_Contract	86% No	37% Yes	85% No

Cluster 2 – 'Earning head and improving food security': This cluster is small and includes mainly households from Sobantu. The household head is older than 41 yrs and a small number of heads receive a pension. Income is primarily from wages, salary or profit. Only one person contributes to household income even though households can be large. Employment is often in manufacturing or agriculture/forestry/fisheries. Income can also come from bursaries and grants. Work is not seasonal but can be contractual. All households receive municipal services which are not always reliable. While most houses have a tap in the house for drinking water, some use taps outside. Affordability of food and food diversity have improved for the typical household. Food is purchased in formal outlets and 31% of households also grow food. Most households spend between 25 and 75% of their income on food.

Cluster 3 = 'Older and somewhat vulnerable to food insecurity but sometimes family members chip in': Half of the Pniel households, one third of those in Lanquedoc, most households in Sobantu and a small number of those in Noordhoek form this cluster. The typical head of the household is over 60 yrs old and receives a pension. Just over half receive an income and some receive a grant. Income is contributed by up to five household members since a high proportion of households have up to seven members. Employment is generally not seasonal but can be contractual. All households receive municipal services and most believe these to be reliable. Almost all households have a tap inside the house for drinking water. The typical household has experienced a decline in food affordability and diversity. Food is always purchased in formal outlets and 64% of households grow food with 17% indicating that this is an important source of food. Most households spend between 25 and 75% of their income on food.

4.2.2 Household variables

The MCA plot (Fig. 19) shows close correspondence between all four communities regarding household characteristics and the variability within each community.

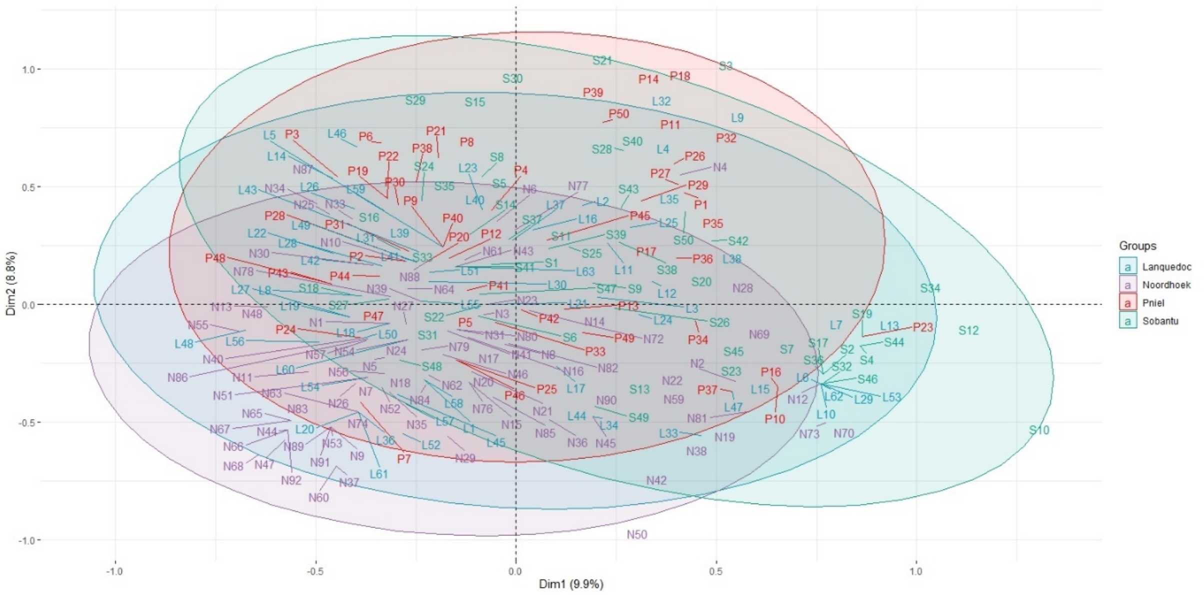


Figure 19 Multiple Correspondence Analysis (MCA) plot showing the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households), and one community in the uMngeni catchment: Sobantu (50 households) in terms of 9 variables (20 columns) relating to household level contextual information. The communities are colour coded and ellipses indicate the extent of variation within the community and overlap with others. Dim = dimension (with % explained variance given in parenthesis), L = Lanquedoc, N= Noordhoek, P = Pniel, S = Sobantu.

Three clusters were delineated as shown in the factor plot (Fig. 20). The significant variables (Fig. 74 in Appendix 3) were analysed and the results presented in Table 15 in decreasing order of statistical significance.

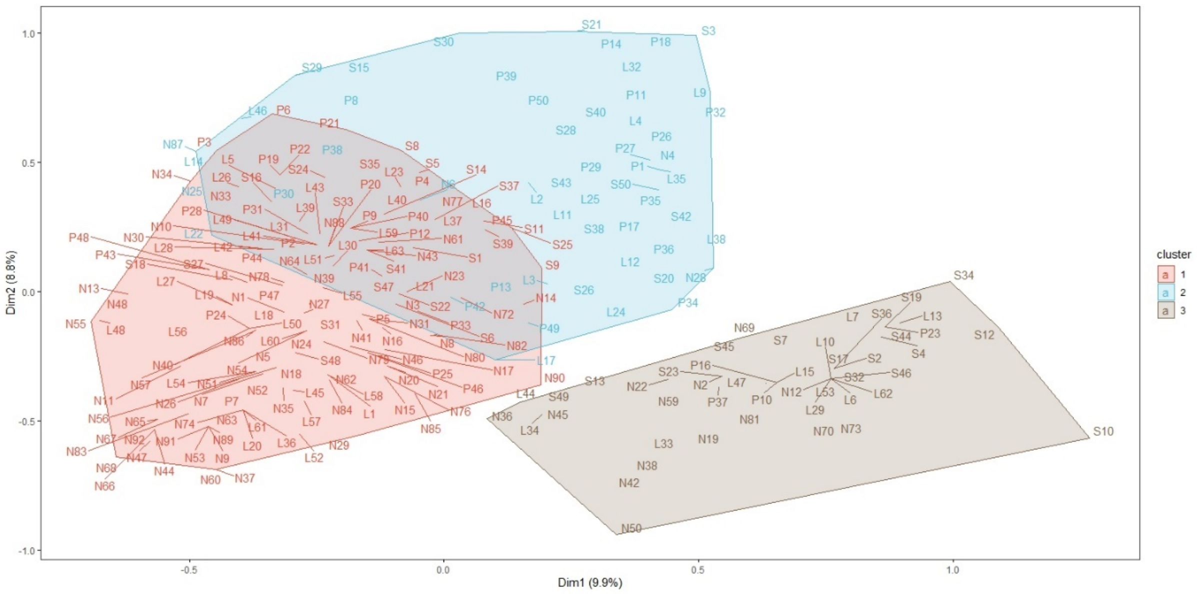


Figure 20 Factor plot visualising the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (92 households) and one community in the uMngeni catchment: Sobantu (50 households) in terms of 9 variables (20 columns) relating to household level contextual information. The first two dimensions are plotted (Dim 1 and 2), with a cumulative explained variance of 18.7%. Clusters of households, and their minimum bounding geometries, are coloured according to three groups which were selected using the corresponding dendrogram and each household is labelled according to its unique ID: L = Lanquedoc, N= Noordhoek, P = Pniel, S = Sobantu.

Cluster narrative (household variables)

Cluster 1 – 'Small and working age: The largest cluster, this includes around half of Pniel and Lanquedoc households, three-quarters of those in Noordhoek, and just under half of Sobantu households. A typical household has a head of working age (20-60 yrs old) and income is from wages, salary or business profit, with no pension. Household size is generally 2-4 persons and one or two people contribute to household income. Employment in agriculture/ forestry/ fisheries is common. Other employment sectors include commercial, government and manufacturing. Jobs are permanent, contractual or seasonal. All households receive municipal services which are seen to be reliable.

Cluster 2 – 'Large, older and collaborative': This cluster includes around half of Pniel households, a minority of households in Lanquedoc and Noordhoek, and around a quarter of Sobantu households. The household head is typically older (mostly older than 60 yrs) with three-quarters of heads drawing a pension. However, all households also receive income from wages, salaries or profit. Large households are common with just under one third having eight or more members. This allows for multiple incomes with most households having three or more members contributing. Employment is found in the sectors agriculture/forestry/fisheries, commercial, government and manufacturing. Most jobs are permanent but seasonal and contract jobs are common. All households receive municipal services which are seen to be reliable by three-quarters of households.

Cluster 3 – ‘Small and older’: A minority of households in Lanquedoc and Noordhoek, and one third of Sobantu households, with just a handful of Pniel households, make up this cluster. A typical household is headed by a pensioner (older than 60 yrs), and does not receive income from wages, salaries or profit. The pensioner is mostly the only household member contributing to income. Most of these households are small (1-4 people) but some can be quite large. All households receive municipal services which are seen to be reliable.

Table 15 Results of Level 2 analysis (Berg communities and Sobantu) based on variables in the household category. H= variables relate to the household. For the full names of the variables, refer to Appendix 3.

Variable	**Cluster 1** 25/49 Pniel 36/63 Lanquedoc 69/87 Noordhoek 21/50 Sobantu **Total: 151**	**Cluster 2** 20/49 Pniel 15/63 Lanquedoc 5/87 Noordhoek 13/50 Sobantu **Total: 53**	**Cluster 3** 4/49 Pniel 12/63 Lanquedoc 13/87 Noordhoek 16/50 Sobantu **Total: 45**
H_MajorIncSou_Income	99% Yes	100% Yes	100% No
H_MajorIncSou_Pension	96% No	74% Yes	76% Yes
H_NoHHContri	62% one person 37% two persons	26% one person 47% three persons 15% four persons 8% five persons	73% one person 18% two persons
H_AgeHH	41% 20-40 yrs 52% 41-60 yrs 7% >60 yrs	28% 41-60 yrs 66% >60 yrs	27% 41-60 yrs 58% >60 yrs
H_MunicServ	100% yes	100% yes	100% Yes
H_EmplType_Permanent	47% Yes	72% Yes	100% No
H_NoHH	58% 2-4 persons 31% 5-7 persons	34% 2-4 persons 38% 5-7 persons 23% 8-10 persons 6% >10 persons	13% single 51% 2-4 persons 24% 5-7 persons
H_EmplSect_AgricForFish	35% Yes	26% Yes	100% No
H_EmplType_Contract	15% Yes	32% Yes	100% No
H_EmplSect_Commercial	28% Yes	40% Yes	98% No
H_EmplSect_Government	21% Yes	36% Yes	100% No
H_EmplSect_Manufacturing	11% Yes	25% Yes	100% No
H_EmplType_Seasonal	25% Yes	17% Yes	100% No
H_EmplSect_Other	15% Yes (Noordhoek)	96% No	98% No
H_MunicServRel	89% Yes	74% Yes	82% Yes

4.2.3 Water-food variables

The MCA plot (Fig. 21) shows close correspondence between the three Berg communities and a sub-section of the Sobantu community regarding water and food characteristics. However, high variability was a feature of the Sobantu community, and low variability was a feature of the Pniel community.

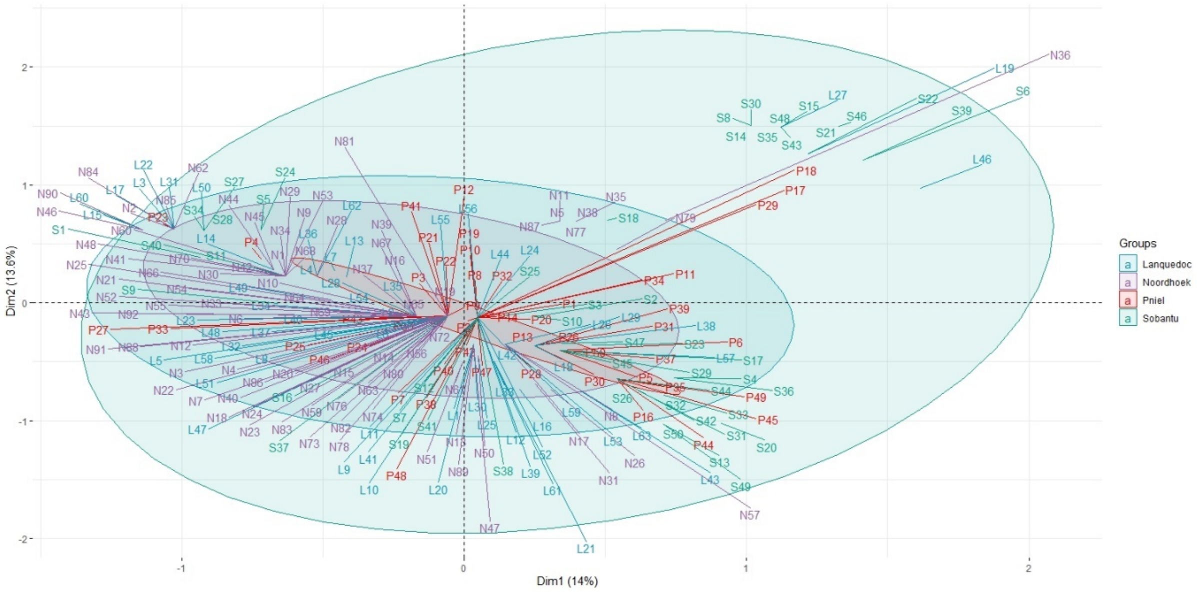


Figure 21 Multiple Correspondence Analysis (MCA) plot showing the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (92 households), and one community in the uMngeni catchment: Sobantu (50 households) in terms of 9 variables (11 columns) relating to water and food information. The communities are colour coded and ellipses indicate the extent of variation within the community and overlap with others. Dim = dimension (with % explained variance given in parenthesis), L = Lanquedoc, N= Noordhoek, P = Pniel, S = Sobantu.

Three clusters were delineated as shown in the factor plot (Fig. 22). The significant variables (Fig. 75 in Appendix 3) were analysed and the results presented in Table 16 in decreasing order of statistical significance.

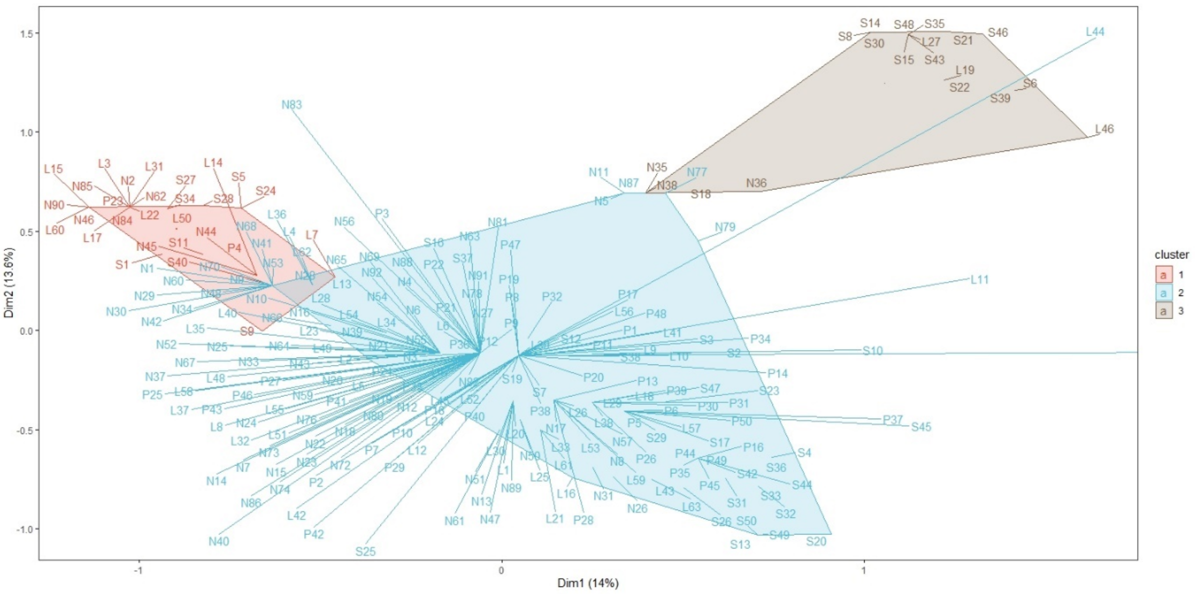


Figure 22 Factor plot visualising the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (92 households) and one community in the uMngeni catchment: Sobantu (50 households) in terms of 9 variables (11 columns) relating to water and food information. The first two dimensions are plotted (dim 1 and 2), with a cumulative explained variance of 27.6%. Clusters of households, and their minimum bounding geometries, are coloured according to three groups which were selected using the corresponding dendrogram and each household is labelled according to its unique ID: L = Lanquedoc, N= Noordhoek, P = Pniel, S = Sobantu.

Cluster narrative (water – food variables)

Cluster 1 – ‘the stable few’: This small cluster includes several households from all four communities. They typically reported to have experienced no change in affordability of food and food diversity over the last few years.

Cluster 2 – ‘declining food security’: Most households occur in this cluster, with a high proportion of households from Pniel, Lanquedoc and Noordhoek, and just over half of Sobantu households. The households have experienced a decline in food affordability and food diversity.

Cluster 3 – ‘the fortunate few’: Another small cluster, this one primarily represents a portion of Sobantu households with a handful each from Lanquedoc and Noordhoek. The typical household has seen improvements in food affordability and food diversity.

Table 16 Results of Level 2 analysis (Berg communities and Sobantu) based on variables in the categories water and food. W= variables relate to water, F = variables relate to food. For the full names of the variables, refer to Appendix 3.

Variable	**Cluster 1** 2/49 Pniel 9/63 Lanquedoc 8/87 Noordhoek 9/50 Sobantu **Total: 28**	**Cluster 2** 47/49 Pniel 51/63 Lanquedoc 76/87 Noordhoek 28/50 Sobantu **Total: 202**	**Cluster 3** 0/49 Pniel 3/63 Lanquedoc 3/87 Noordhoek 13/50 Sobantu **Total: 19**
F_FoodAfford	100% Same	100% Declined	100% Improved
F_FoodLoca_Formal	100% Yes	100% Yes	100% Yes
F_FoodDivers	86% Same	87% Declined	79% Improved

Although the households from the four different communities did not cluster separately (i.e. intra-community variation was greater than inter-community variation) there are some clear differences in terms of water and food. In all four communities, there were some 'stable few', some 'fortunate few', with a majority of 'declining food security'. This suggests that whatever is driving these differences in the WEF nexus in these communities is not related to context-specific challenges, but rather more global economic drivers such as the struggling national economy, or national service delivery issues.

4.3 Level 3: A comparison of five communities in the Berg and Keiskamma catchments

4.3.1 All variables

The MCA plot (Fig. 23) shows how the data from the five communities separated relatively neatly in the first dimension into the two Keiskamma communities (Hamburg and Melani) on the left of the X-axis in Fig. 23, and the three Berg communities (Pniel, Lanquedoc, Noordhoek) on the right of the X-axis. Limited overlap between the two sets of clusters can be observed, and an entire overlap can be seen with regard to the communities of Lanquedoc, Hamburg and Melani.

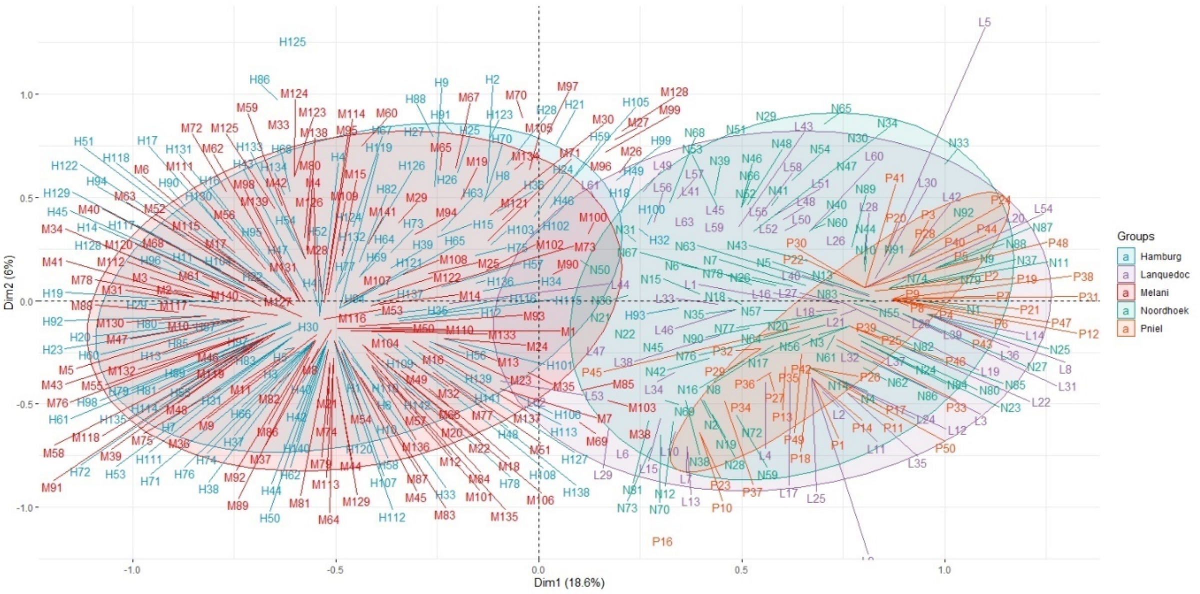


Figure 23 Multiple Correspondence Analysis (MCA) plot showing the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households), and two communities in the Keiskamma catchment: Hamburg (142 households) and Melani (141 households), in terms of 14 variables (21 columns) relating to household level contextual information as well as water and energy. The communities are colour coded and ellipses indicate the extent of variation within the community and overlap with others. Dim = dimension (with % explained variance given in parenthesis). L = Lanquedoc, N = Noordhoek, P = Pniel, H = Hamburg, M = Melani.

Two clusters were delineated as shown in the factor plot (Fig. 24). The significant variables (Fig. 76 in Appendix 3) were analysed with respect to each cluster, and the results presented in Table 17 in decreasing order of statistical significance.

Cluster narrative (all variables)

Cluster 1 – 'water and energy poor': This cluster includes all households in the two Keiskamma communities, except 6 in Hamburg and 10 in Melani. It includes only 3 households from Lanquedoc (Berg community). Households are mainly supported by grants and most household heads are not employed, so that income from wages, salaries or profits is limited. Households are mostly headed by females (72%), and more than half are older than 60 years, with few household heads younger than 40 years. Water related services are a major challenge: most households access drinking water from a private or communal tap outside the house or a neighbour's tap. Flush toilets are rare, and water demand is generally not met. Wood, paraffin and manure are widely used as energy sources. Access to energy varied highly, with households indicating improved as well as declined access (some remained the same) but energy affordability mostly declined.

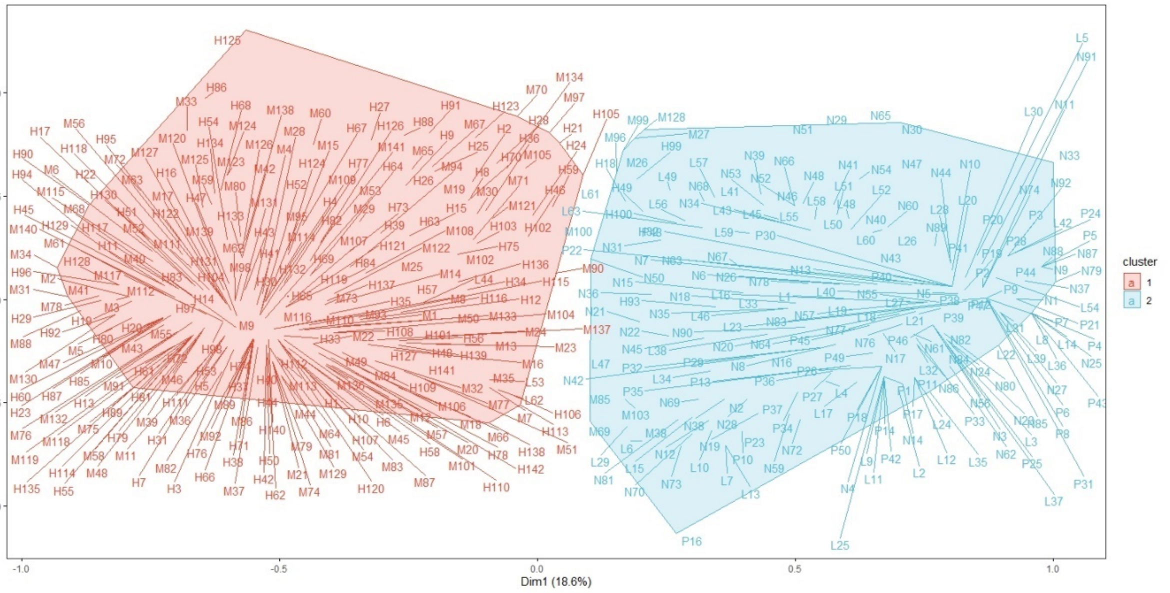


Figure 24 Factor plot visualising the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households), and two communities in the Keiskamma catchment: Hamburg (142 households) and Melani (141 households), in terms of 14 variables (21 columns) relating to household level contextual information as well as water and energy. The first two dimensions are plotted (Dim 1 and 2), had a cumulative explained variance of 24.6%. Clusters of households, and their minimum bounding geometries, are coloured according to two groups which were selected using the corresponding dendrogram and each household is labelled according to its unique ID: L = Lanquedoc, N = Noordhoek, P = Pniel, H = Hamburg, M = Melani.

Cluster 2 – 'water and energy serviced': All except 3 households in the Berg communities are part of this cluster, as well as 16 households from the Keiskamma. Households predominantly receive income from wages, salaries or profit, and have equal numbers of female- and male-headed households where the head is generally employed and younger than 60 years old. Drinking water is available in the house or yard in three quarters of households, flush toilets are used in a high proportion of households, and water demand is generally met. Wood, paraffin, manure and candles are not used by most households. Energy access declined in 27% of households and remained the same in most of the other households. Energy affordability declined or remained the same.

Table 17 Results of Level 3 analysis (Berg and Keiskamma communities) based on variables in the categories household, water and energy. H= variables relate to the household, E= variables relate to energy, W= variables relate to water. For the full names of the variables, refer to Appendix 3.

Variable	**Cluster 1** 0/49 Pniel 3/63 Lanquedoc 0/87 Noordhoek 136/142 Hamburg 131/141 Melani **Total: 270**	**Cluster 2** 49/49 Pniel 60/63 Lanquedoc 87/87 Noordhoek 6/142 Hamburg 10/141 Melani **Total: 212**
W_ToilFac	7% Flush 93% Non-flush	91% Flush 9% Non-flush
E_EnSou_All_Wood	84% Yes	92% No
W_DrinkWaterSouDist	5% Inside 95% Outside	75% Inside 25% Outside
H_MajorIncSou_Income	86% No	85% Yes
W_MajorDrinkWatSou	5% Tap inside 61% Tap outside 7% Tap neighbour 22% Tap communal	74% Tap inside 21% Outside 3% Tap neighbour/ main house
H_EmplStatus	93% Unemployed	74% Employed
W_WaterDemMet	81% No	79% Yes
H_MajorIncSou_Grant	84% Yes	36% Yes
E_EnSou_All_Paraf	56% Yes	91% No
E_EnergyAccess	38% Declined 24% Same 38% Improved	28% Declined 64% Same 8% Improved
H_AgeHH	9% 20-40 yrs 36% 41-60 yrs 55% >60 yrs	32% 20-40 yrs 43% 41-60 yrs 24% >60 yrs
E_EnSou_All_Man	19% Yes	99% No
E_EnergyAfford	61% Declined 19% Same 20% Improved	63% Declined 34% Same 3% Improved
H_GenderHH	28% Male 72% Female	50% Male 50% Female
E_EnSou_All_Candl	100% No	98% No
H_MajorIncSou_Remitt	2% Yes	100% No

4.4 Level 4: A comparison of three communities within the Berg catchment

4.4.1 All variables

The MCA plot (Fig. 25) shows that Lanquedoc has high variability in both dimensions, Noordhoek is a sub-set of Lanquedoc with similar variability in the first dimension but lower variability in the second dimension. Pniel shows a much smaller variability in both dimensions than the other two.

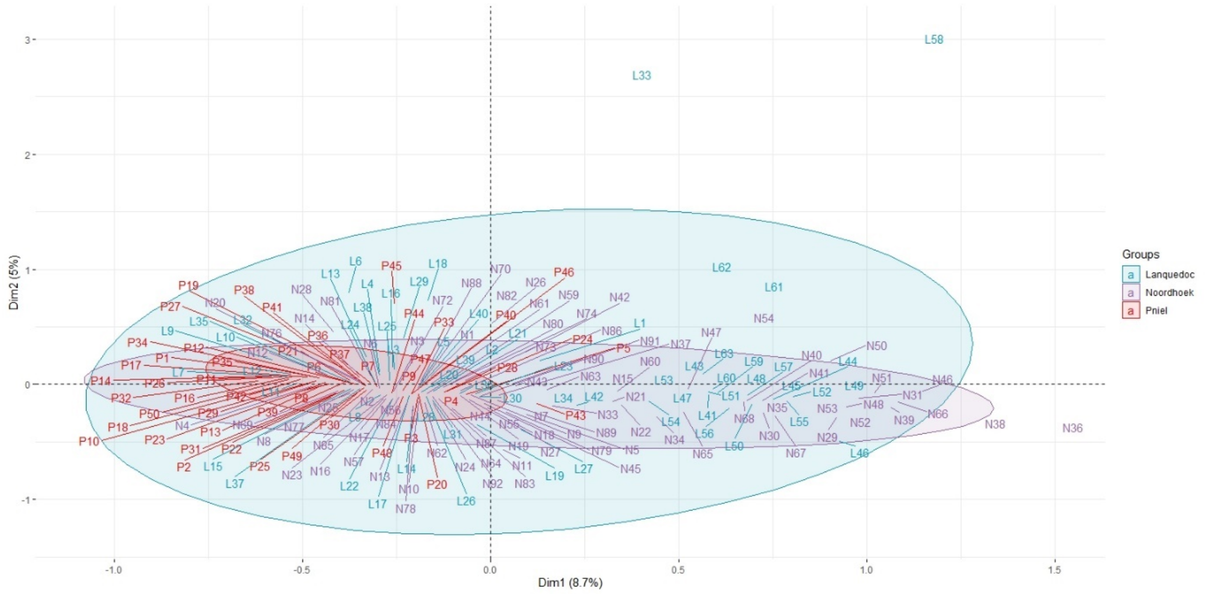


Figure 25 Multiple Correspondence Analysis (MCA) plot showing the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 36 variables (51 columns) relating to household level contextual information as well as the water-energy-food nexus. The communities are colour coded and ellipses indicate the extent of variation within the community and overlap with others. Dim = dimension (with % explained variance given in parenthesis), L = Lanquedoc, N= Noordhoek, P = Pniel.

Four clusters were delineated as shown in the factor plot (Fig. 26). The significant variables (Fig. 77 in Appendix 3) were analysed and the results presented in Table 18 in decreasing order of statistical significance.

Cluster narrative (all variables)

Cluster 1 – ‘WEF secure rooted community’: This is a medium-sized cluster, including just under half of Pniel households, almost one third of households from Lanquedoc, and a handful of Noordhoek households. Almost all the households are headed by a pensioner of over 6o years of age who has lived in their respective community for a long time. While just over half the households have 1-4 members, a large proportion houses a large family (≥5 members). The dwelling is typically a main house built of brick. The pension is often supplemented with income provided by several other household members. Employment sectors include agriculture/forestry/fisheries and government. Nevertheless, finances are the main challenge for half the households, and health is also of concern. All households use mainly electricity as their primary energy source with very little use of alternative energy sources. Overall, demand is met in most households. Drinking water is accessed by a tap inside the house, and almost all houses have their own flush toilet. Household water demand is almost always met. The only significant characteristics relating to food are that these households generally reported a decline in food diversity.

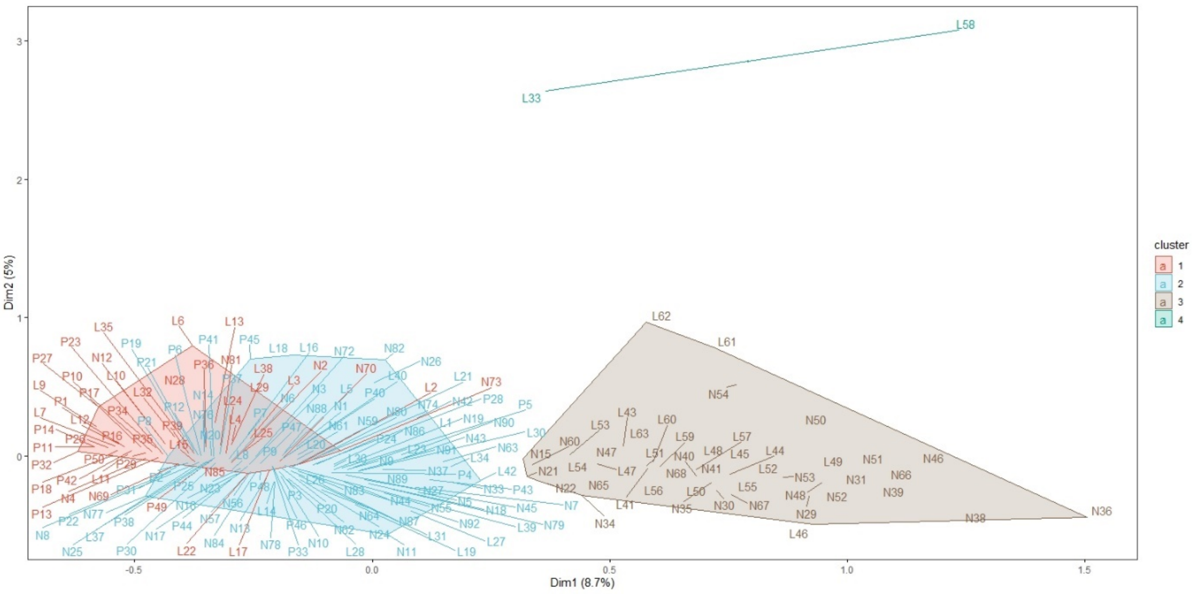


Figure 26 Factor plot visualising the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 36 variables (51 columns) relating to household level contextual information as well as the water-energy-food nexus. The first two dimensions are plotted (dim 1 and 2), with a cumulative explained variance of 13.7%. Clusters of households, and their minimum bounding geometries, are coloured according to five groups which were selected using the corresponding dendrogram and each household is labelled according to its unique ID: L = Lanquedoc, N= Noordhoek, P = Pniel.

Cluster 2 – 'WEF semi-secure growing roots': This is the largest cluster. More than half of Pniel households are in this cluster, one third of Lanquedoc households, and the largest proportion of households in Noordhoek. They are headed mostly by middle-aged persons who have lived within their respective community for a long time; although some households were established more recently and have younger heads. A smaller household size is more common, although one third have 5-7 members. The dwelling is usually a main house built of brick. Very few households receive a pension, and income is mostly generated by one or two household members, working in the sectors agriculture/forestry/fisheries and/or government. Some households receive grants. The most frequently reported challenge is that of financial security. All households use electricity as their primary energy source, although one quarter also use gas for cooking. Energy demand is generally met. Almost all households obtain drinking water from a tap inside the house and have their own flush toilet. Water demand is generally met although less than in Cluster 1. A decline in food diversity was experienced by most households over the last years.

Cluster 3 = 'WEF semi-insecure unsettled': One third of Lanquedoc households and one third of Noordhoek households make up this cluster. The head of the household is typically younger than those of clusters 1 and 2 and has lived in the community for less than 10 years. Households generally have up to 4 members. The dwelling is commonly a backyard structure built of zinc metal sheets. One third of households rely on income from a single person, the other two-thirds of the households rely on two people for income. Employment is in many cases found in the sector agriculture/forestry/fisheries and is often casual. Several of these households also receive grants. All households use electricity as their primary energy source, but several also use gas for cooking. Energy demand is met in most households but fewer compared to Clusters 1 and 2. Most households obtain their drinking water from a tap outside the dwelling. Communal flush and other toilet facilities are common, making a higher proportion than own flush toilet. It does, therefore, not surprise that sanitation challenges are cited by several households. However, finances are listed as a more severe challenge. Water demand is met in most households but fewer compared to Clusters 1 and 2. Food diversity has declined over the years in most households, and a tenth of households engage in foraging for food.

Cluster 4 = ‘Energy insecure’: This is an outlier cluster consisting of only two households in Lanquedoc. They both have no access to electricity and use wood for cooking and candles for lighting. Energy demand is thus not met. The household heads differ in terms of age but are both not pensioners. One of the households reported disability as a major challenge. Drinking water is accessed by means of a tap in both cases and water demand is apparently met. Both households report a declining food diversity in their diets and one household engages in foraging for food.

Table 18 Results of Level 4 analysis (Berg communities) based on all variables in four categories. H= variables relate to the household, E= variables relate to energy, W= variables relate to water, F = variables relate to food. For the full names of the variables, refer to Appendix 3.

Variable	Cluster 1 20/49 Pniel 19/63 Lanquedoc 9/87 Noordhoek Total: 48	Cluster 2 29/49 Pniel 21/63 Lanquedoc 52/87 Noordhoek Total: 102	Cluster 3 0/49 Pniel 21/63 Lanquedoc 26/87 Noordhoek Total: 47	Cluster 4 0/49 Pniel 2/63 Lanquedoc 0/87 Noordhoek Total: 2
E_EnSou_All_Elec	100% Yes	100% Yes	100% Yes	100% No
W_DrinkWaterSouDist	100% Inside	99% Inside	89% Outside	50% Inside 50% Outside
H_AgeHH	2% 20-40 yrs 8% 41-60 yrs 90% >60 yrs	27% 20-40 yrs 67% 41-60 yrs 6% >60 yrs	68% 20-40 yrs 26% 41-60 yrs 4% >60 yrs	50% 20-40 yrs 50% 41-60 yrs
W_MajorDrinkWatSou	96% Tap inside	94% Tap inside	83% Tap outside	50% Tap inside
H_MajorIncSou_Pension	94% Yes	94% No	91% No	100% No
H_DwellStruct	100% Brick	90% Brick	72% Zinc	50% Brick 50% Zinc
H_DwellType	100% Main	93% Main	77% Backyard	50% Main 50% Backyard
E_EnSou_All_Candl	100% No	99% No	98% No	100% Yes
W_ToilFac	98% Own flush	98% Own flush	43% Own flush 38% Communal flush 19% Other	50% Own flush 50% Communal flush
H_NoHHContri	23% one person 15% two people 42% three people 15% four people 6% five people	46% one person 44% two people 7% three people 2% four people	66% one person 30% two people	50% none 50% one person
H_MajorChall	52% Finances 21% None 18% Health	62% Finances 21% None	36%Finances 30% None 13% Sanitation 9% Health	50% Disability 50% None
E_EnSou_Cooking_All	90% Electricity (+wood)	72% Electricity (+gas+wood) 25% Gas	79% Electricity 17% Gas	100% Wood
H_DurRes	23% 11-20 yrs 75% >20 yrs	17% 3-10 yrs 27% 11-20 yrs 45% >20 yrs	30% 0-2 yrs 30% 3-10 yrs 28% 11-20 yrs 12% >20 yrs	50% 11-20 yrs 50% >20 yrs
E_EnSou_All_Wood	92% No	95% No	96% No	100% Wood
H_NoHH	4% single 52% 2-4 people 29% 5-7 people 12% 8-10 people	3% single 59% 2-4 people 31% 5-7 people 2% 8 or more	26% single 57% 2-4 people 17% 5-7 people	50% 2-4 persons 50% 8-10 persons
W_OtherWaterSou	48% Tap 52% Tap and other	67% Tap 27% Tap and other	91% Tap 4% Tap and other	50% Tap 50% Tap and other
W_WaterDemMet	94% Yes	86% Yes	62% Yes	100% Yes
E_EnergyDemMet	85% Yes	85% Yes	68% Yes	100% No
H_EmplType_Casual	92% No	96% No	21% Yes	50% Yes
F_Foraging	100% No	96% No	11% Yes	50% Yes
H_EmplSect_Government	23% Yes	28% Yes	96% No	100% No
H_MajorIncSou_Grant	100% No	11% Yes	21% Yes	100% No
F_FoodDivers	77% Declined	83% Declined	66% Declined	100% Declined
H_EmplSect_AgricForFish	17% Yes	34% Yes	43% Yes	50% Yes

4.4.2 Household variables

According to the MCA plot (Fig. 27), all communities are rather similar with ellipses indicating high levels of overlap. Lanquedoc and Noordhoek have higher variability in both dimensions. Pniel shows a much smaller variability in both dimensions than the other two but is not separated from the other two, rather it is enclosed.

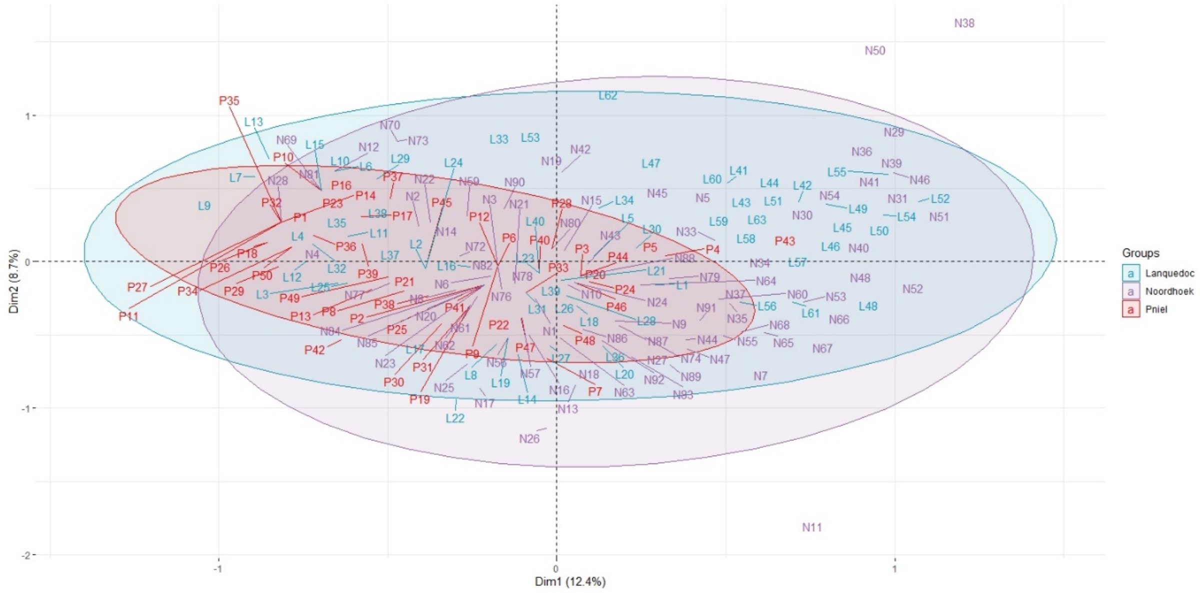


Figure 27 Multiple Correspondence Analysis (MCA) plot showing the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 12 variables (22 columns) relating to household level contextual information. The communities are colour coded and ellipses indicate the extent of variation within the community and overlap with others. Dim = dimension (with % explained variance given in parenthesis), L = Lanquedoc, N= Noordhoek, P = Pniel.

The factor plot (Fig. 28) shows the three clusters, with cluster separation occurring mainly in the first dimension. Clusters 1 and 2 show a small overlap. The significant variables (Fig. 78 in Appendix 3) were analysed and the results presented in Table 19 in decreasing order of statistical significance.

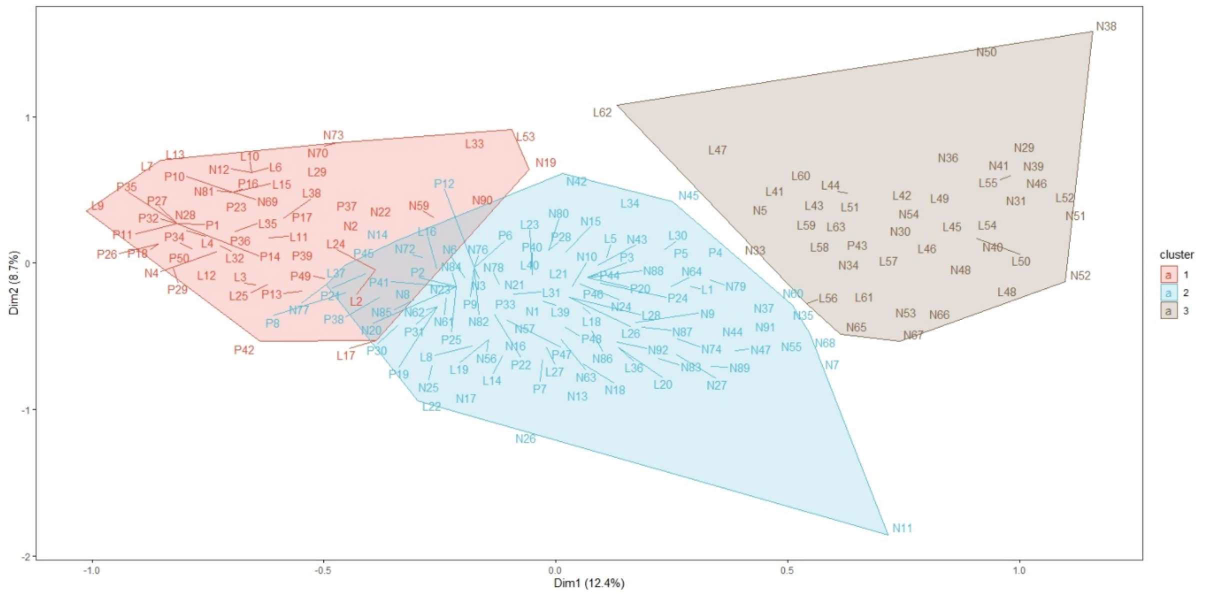


Figure 28 Factor plot visualising the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 12 variables (22 columns) relating to household level contextual information. The first two dimensions are plotted (dim 1 and 2), with a cumulative explained variance of 21.1%. Clusters of households, and their minimum bounding geometries, are coloured according to three groups which were selected using the corresponding dendrogram and each household is labelled according to its unique ID: L = Lanquedoc, N= Noordhoek, P = Pniel.

Cluster narrative (household variables)

Cluster 1 – ‘Rooted community’: This is a medium-sized cluster, including just under half of Pniel households, almost one third of households from Lanquedoc, and a handful of Noordhoek households. Most of the households are headed by a pensioner over 60 years of age who has lived in this community for a long time. While more than half the households have 1-4 members, a large proportion houses a large family. The dwelling is typically a main house built of brick. The pension is often supplemented with income provided by several other household members. Employment sectors include agriculture/forestry/fisheries.

Cluster 2 – ‘Growing roots’: This is the largest cluster. More than half of Pniel households are in this cluster, one third of Lanquedoc households, and the largest proportion of households in Noordhoek. They are headed mostly by middle-aged persons who have lived there for a long time, although some households were established more recently and have younger heads. A smaller household size is more common, although one third have 5-7 members. The dwelling is usually a main house built of brick. Almost no households receive a pension, and income (wage, salary or profit) is mostly generated by one or two household members, some working in the sectors agriculture/forestry/fisheries and government. Seasonal work is common.

Cluster 3 = ‘Unsettled’: One third of Lanquedoc households and one third of Noordhoek households make up this cluster. The head of the household is typically younger than those of Clusters 1 and 2 and has lived in the community for less than 10 years. Households generally have up to 4 members. The dwelling is commonly a backyard structure built of zinc metal sheets or wood. Income (wage, salary or profit) is contributed by a single person or otherwise two people. Employment is in many cases found in agriculture/forestry/fisheries; seasonal and casual work are common.

Table 19 Results of Level 4 analysis (Berg communities) based on variables in the household category. H= variables relate to the household. For the full names of the variables, refer to Appendix 3.

Variable	**Cluster 1** 21/49=Pniel 20/63=Lanquedoc 12/87=Noordhoek **Total: 53**	**Cluster 2** 27/49=Pniel 21/63=Lanquedoc 54/87=Noordhoek **Total: 102**	**Cluster 3** 1/49=Pniel 22/63=Lanquedoc 21/87=Noordhoek **Total: 44**
H_MajorIncSou_Pension	94% Yes	97% No	95% No
H_DwellType	98% Main	97% Main	91% Backyard
H_DwellStruct	98% Brick	90% Brick	70% Zinc 23% Wood
H_AgeHH	15% 41-60 yrs 81% >60 yrs	26% 20-40 yrs 67% 41-60 yrs 7% >60 yrs	75% 20-40 yrs 20% 41-60 yrs
H_DurRes	21% 11-20 yrs 74% >20 yrs	8% 0-2 yrs 14% 3-10 yrs 31% 11-20 yrs 45% >20 yrs	32% 0-2 yrs 36% 3-10 yrs 23% 11-20 yrs
H_NoHHContri	26% one person 17% 2 people 38% 3 people 17% 4-5 people	47% one person 42% 2 people 7% 3 people	64% one person 32% 2 people
H_MajorIncSou_Income	60% Yes	97% Yes	86% Yes
H_NoHH	7% single 53% 2-4 people 26% 5-7 people 13% 8-10 people	2% single 59% 2-4 people 36% 5-7 people 3% 8 or more	25% single 61% 2-4 people 14% 5-7 people
H_EmplSect_AgricForFish	13% Yes	37% Yes	43% Yes
H_EmplType_Seasonal	92% No	27% Yes	16% Yes
H_EmplType_Casual	91% No	95% No	20% Yes

4.4.3 All WEF variables

According to the MCA plot (Fig. 29), Lanquedoc and Noordhoek have high variability in both dimensions but diverge more in the second dimension. Pniel shows a much smaller variability in both dimensions.

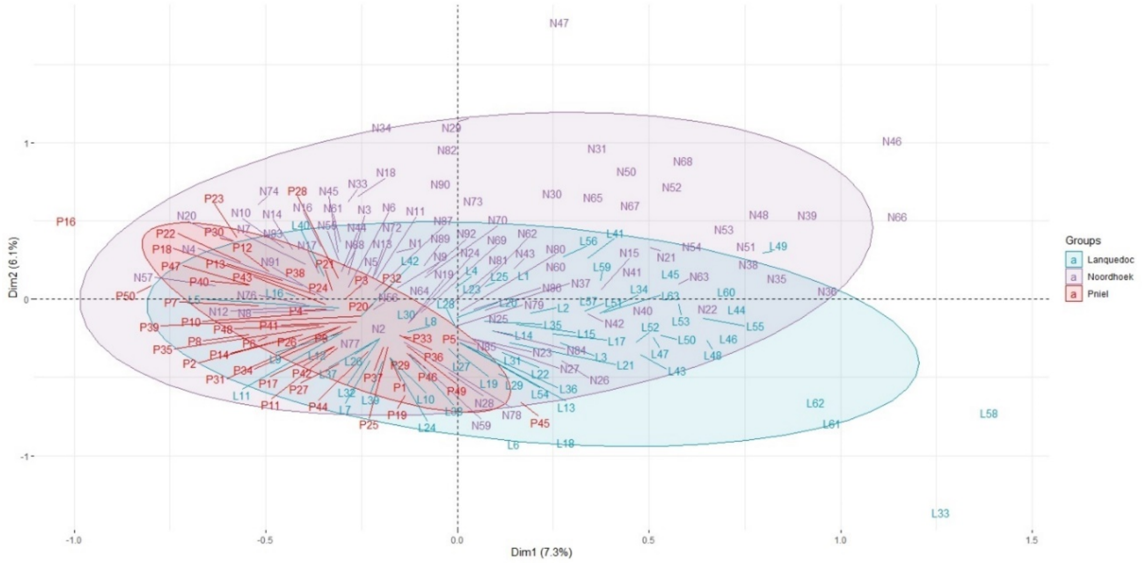


Figure 29 Multiple Correspondence Analysis (MCA) plot showing the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 24 variables (29 columns) relating to WEF information. The communities are colour coded and ellipses indicate the extent of variation within the community and overlap with others. Dim = dimension (with % explained variance given in parenthesis), L = Lanquedoc, N= Noordhoek, P = Pniel.

The factor plot (Fig. 30) shows the five clusters. Clusters 1 and 2 show considerable overlap. Clusters 3 and 4 are well separated from the other clusters with minimal overlap. Cluster 5 is completely distinct. The significant variables (Fig. 79 in Appendix 3) were analysed and the results presented in Table 20 in decreasing order of statistical significance.

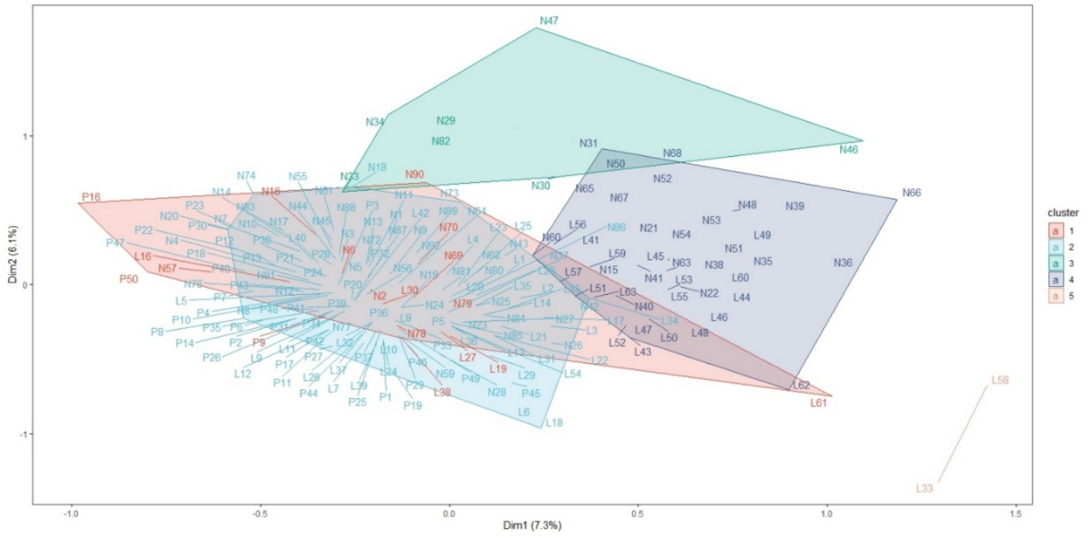


Figure 30 Factor plot visualising the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 24 variables (29 columns) relating to WEF information. The first two dimensions are plotted (dim 1 and 2), with a cumulative explained variance of 13.4%. Clusters of households, and their minimum bounding geometries, are coloured according to five groups which were selected using the corresponding dendrogram and each household is labelled according to its unique ID: L = Lanquedoc, N= Noordhoek, P = Pniel.

Table 20 Results of Level 4 analysis (Berg communities) based on the categories water, energy and food. E= variables relate to energy, W= variables relate to water, F = variables relate to food. For the full names of the variables, refer to Appendix 3.

Variable	**Cluster 1** 3/49=Pniel 6/63=Lanquedoc 9/87=Noordhoek **Total: 18**	**Cluster 2** 46/49=Pniel 36/63=Lanquedoc 49/87=Noordhoek **Total: 131**	**Cluster 3** 0/49=Pniel 0/63=Lanquedoc 7/87=Noordhoek **Total: 7**	**Cluster 4** 0/49=Pniel 19/63=Lanquedoc 22/87=Noordhoek **Total: 41**	**Cluster 5** 0/49=Pniel 2/63=Lanquedoc 0/87=Noordhoek **Total: 2**
W_MajorDrinkWatSou	100% Tap inside	100% Tap inside	29% Tap inside 57% Tap main house	90% Tap outside	50% Tap inside
E_EnSou_All_Elec	100% Yes	100% Yes	100% Yes	100% Yes	100% No
W_DrinkWaterSouDist	94% Inside	100% Inside	86% Inside	100% Outside	50% Inside
E_EnSou_All_Candl	100% No	100% No	14% Yes	98% No	100% Yes
W_WaterAfford	33% Declined 11% Same 56% Improved	70% Declined 29% Same	71% Declined 29% Same	41% Declined 59% Same	50% Declined 50% Same
W_ToilFac	94% Own flush	99% Own flush	29% Own flush 29% Communal flush 43% Other	44% Own flush 41% Communal flush 15% Other	50% Own flush 50% Communal flush
W_OtherWaterSou	50% Tap 50% Tap and other	66% Tap 34% Tap and other	43% Tap 14% Tap and other 43% Other	95% Tap	50% Tap 50% Tap and other
W_WaterQual	22% Declined 22% Same 50% Improved	37% Declined 63% Same	43% Declined 43% Same	17% Declined 80% Same	100% Same
E_EnergyAfford	39% Declined 33% Same 28% Improved	70% Declined 30% Same	100% Declined	46% Declined 51% Same	50% Declined 50% Same
E_EnSou_Cooking_All	72% Electricity (+gas) 22% Gas 6% Wood	77% Electricity (+gas+wood) 20% Gas	57% Electricity (+gas) 43% Gas	85% Electricity 12% Gas	100% Wood
E_EnSou_All_Wood	94% No	93% No	100% No	98% No	100% Yes
F_FoodExpend	44% <25% 33% <50% 11% <75% 11% <100%	7% <12.5% 14% <25% 47% <50% 27% <75% 5% <100%	71% <12.5% 14% <25% 14% <50%	7% <12.5% 34% <25% 32% <50% 17% <75% 5% <100%	100% <50%

Variable	Cluster 1 3/49=Pniel 6/63=Lanquedoc 9/87=Noordhoek **Total: 18**	Cluster 2 46/49=Pniel 36/63=Lanquedoc 49/87=Noordhoek **Total: 131**	Cluster 3 0/49=Pniel 0/63=Lanquedoc 7/87=Noordhoek **Total: 7**	Cluster 4 0/49=Pniel 19/63=Lanquedoc 22/87=Noordhoek **Total: 41**	Cluster 5 0/49=Pniel 2/63=Lanquedoc 0/87=Noordhoek **Total: 2**
E_EnergyDemMet	100% Yes	86% Yes	57% Yes	68% Yes	100% No
W_WaterDemMet	78% Yes	91% Yes	57% No	68% Yes	100% Yes
F_Foraging	89% No	98% No	100% No	90% No	50% Yes
W_WaterAccess	22% Declined 50% Same 28% Improved	20% Declined 74% Same 6% Improved	71% Declined 29% Same	15% Declined 76% Same 7% Improved	50% Declined 50% Same
F_GrowFood	39% Yes	58% Yes	100% No	54% Yes	100% Yes
F_FoodDivers	67% Declined 16% Same 17% Improved	82% Declined 15% Same	43% Declined 57% Same	73% Declined 22% Same	100% Declined

Cluster narrative (WEF variables)

Cluster 1 – 'WEF stable or improving for most, with indoor water and toilet': This is a small cluster with around 6-10% of households from each community. Drinking water is accessed by a tap inside the house, and water for other household uses is available from a tap, sometimes supplemented from other sources. Almost all houses have their own flush toilet. Household water demand is generally met. A feature of this cluster is that around 70% or more of the households reported that water affordability, water quality, and water access have either remained the same or have improved over the last few years. All households use mainly electricity as their primary energy source, although gas is also used for cooking by some. Wood is not commonly used. Demand for energy is met in all the households. Around 60% of households in this cluster feel that energy affordability has either remained the same or improved. Food expenditure is generally up to 50% of income although some households spend up to 100%. A relatively high proportion of households grow food, but foraging is uncommon. Food diversity has declined in many households but 17% reported an improvement in food diversity.

Cluster 2 – 'WEF affordability declining, with indoor water and toilet': This is the largest cluster. All households in Pniel (except those in cluster 1), and just over half of Lanquedoc and Noordhoek households are in this cluster. All households obtain drinking water from a tap inside the house, sometimes supplemented from other sources. Almost all households have their own flush toilet. Water demand is generally met. In this cluster, most of the households reported that water affordability and water quality have declined, but water access has remained the same or even improved over the last few years. All households use electricity as their primary energy source, although one quarter also use gas for cooking. Energy demand is generally met. Around 70% of households feel that energy affordability has declined. Food expenditure is generally up to 50% of income although some households spend more. A high proportion of households grow food, but foraging is uncommon. Food diversity has declined in most households.

Cluster 3 = 'WEF affordability declining, and challenges with access to water and safe sanitation': This small cluster is made up of a handful of Noordhoek households. They are characterised mainly by their sanitation challenges and poor access to water for household use. More than half of these households access their drinking water in the main house (i.e. they are backyard dwellers) and quite a few go outside to collect drinking water. Water used for other household purposes mostly comes from a tap, but just under half of the households turn to 'other' sources. Toilet facilities are primarily communal flush or 'other' (e.g. bucket toilet). Water demand is not met in most of the households. Over the last few years, water has become less affordable and less accessible in most of the households, and water has often declined in quality. The primary source of energy is electricity, but this has become less affordable in all the households. Many households also use gas for cooking and some use candles for lighting. The household energy demand is not met in just under half the households. Up to 50% of income is spent on food, and in most households only up to 12.5% which is very low and suggests that there is insufficient income left after other monthly expenses (rent, water, electricity) are deducted. Food is not grown (likely linked to lack of land) or foraged. However, most of these households reported that food diversity has remained the same, with the others reporting a decline.

Cluster 4 = ‘WEF affordability stable or declining, and challenges with outside water sources and sanitation’: This is the second largest cluster, including one third of households in Lanquedoc and one quarter of Noordhoek households. A high proportion of the households access their drinking water from a tap outside their dwelling. Almost all other household water also comes from a tap. ‘Other’ toilets (e.g. bucket toilets) do exist but most households use either their own or a communal flush toilet. Water demand is met in most of the households although several reported that it was not met. Water affordability, access and quality have remained the same in most households although many have reported a decline (especially affordability). The primary source of energy is electricity, but several households use gas for cooking. Energy has become less affordable in around half of the households, and the energy demand is not met in around one third of the households. In most households, up to 50% of income is spent on food, but rarely less than 12.5%. Just over half of the households grow food and a small proportion forage for food. Food diversity has declined in around three quarters of the households.

Cluster 5 = ‘Energy insecure’: This is a completely distinct cluster consisting of only two households in Lanquedoc. They both have no access to electricity and use wood for cooking (with wood being the primary energy source) and candles for lighting. Energy demand is thus not met. Drinking water is accessed by means of a tap in both cases (either inside or outside) and water demand is apparently met. Both households have access to a flush toilet (own or communal). Both households report a declining food diversity in their diets and one household engages in foraging for food. One of the households reported declining affordability of water and energy and access to water, while the other household found these to be stable.

4.4.4 Water variables

For water, the MCA plot (Fig. 31) shows that Noordhoek has high variability in both dimensions, Lanquedoc has high variability mostly in the first dimension, and Pniel has very low variability in both dimensions.

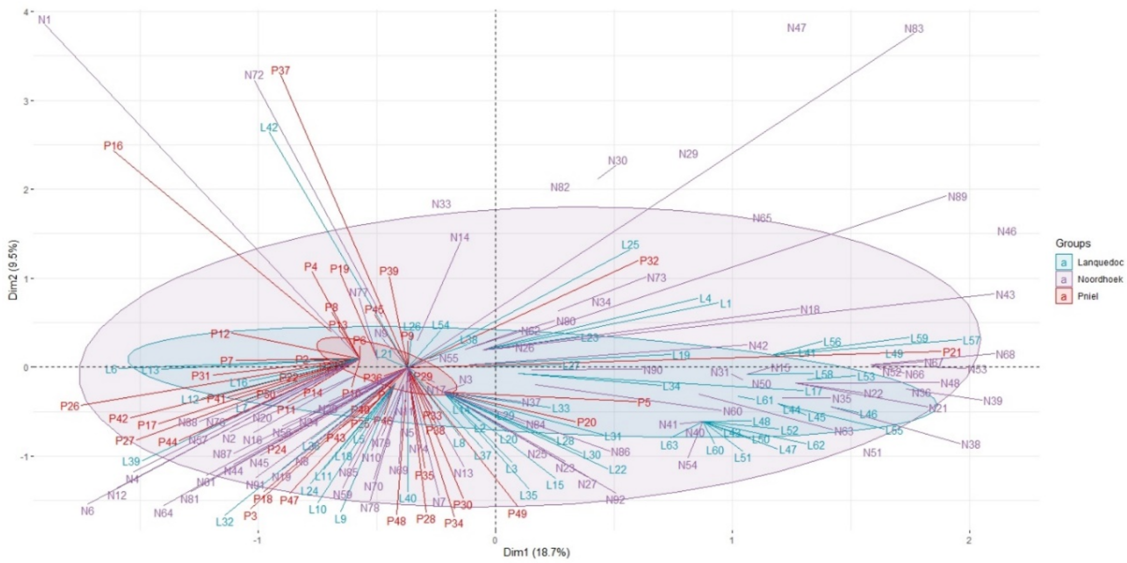


Figure 31 Multiple Correspondence Analysis (MCA) plot showing the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 11 variables (11 columns) relating to water information. The communities are colour coded and ellipses indicate the extent of variation within the community and overlap with others. Dim = dimension (with % explained variance given in parenthesis), L = Lanquedoc, N= Noordhoek, P = Pniel.

The factor plot (Fig. 32) shows two clusters, with no overlap. The significant variables (Fig. 80 in Appendix 3) were analysed and the results presented in Table 21 in decreasing order of statistical significance.

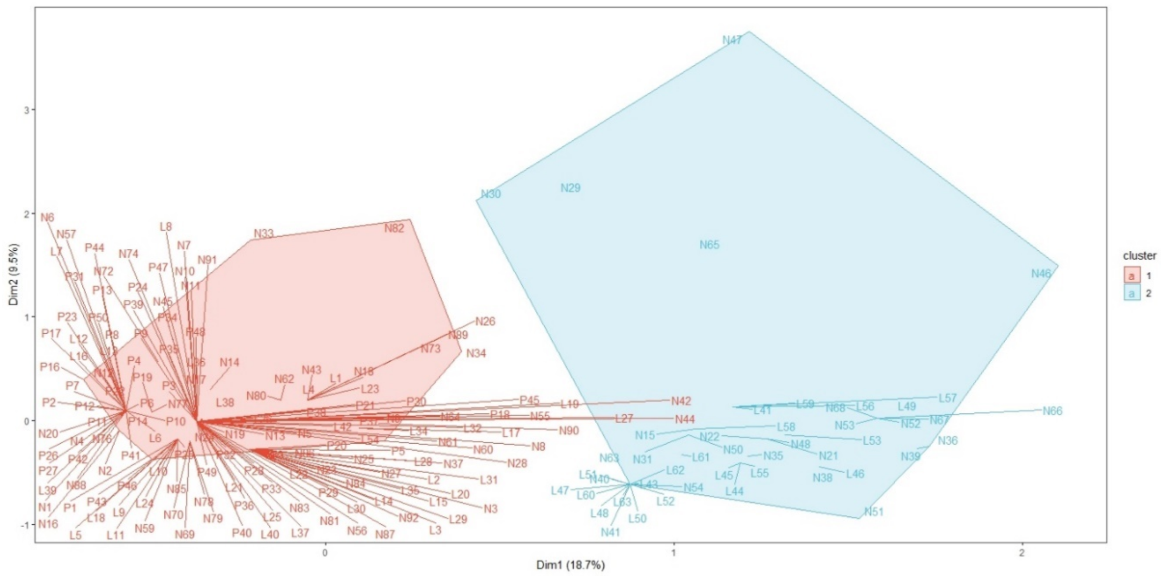


Figure 32 Factor plot visualising the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 11 variables (11 columns) relating to water information. The first two dimensions are plotted (dim 1 and 2), with a cumulative explained variance of 28.2%. Clusters of households, and their minimum bounding geometries, are coloured according to two groups which were selected using the corresponding dendrogram and each household is labelled according to its unique ID: L = Lanquedoc, N= Noordhoek, P = Pniel.

Table 21 Results of Level 4 analysis (Berg communities) based on variables in the water category. W= variables relate to water. For the full names of the variables, refer to Appendix 3.

Variable	Cluster 1 49/49=Pniel 42/63=Lanquedoc 62/87=Noordhoek Total: 153	Cluster 2 0/49=Pniel 21/63=Lanquedoc 25/87=Noordhoek Total: 46
W_DrinkWaterSouDist	99% Inside	93% Outside
W_MajorDrinkWatSou	99% Tap inside	90% Tap outside
W_ToilFac	98% Own flush	39% Own flush 43% Communal flush 17% Other
W_WaterDemMet	10% No 90% Yes	40% No 60% Yes
W_OtherWaterSou	64% Tap 35% Both tap and other	89% Tap 7% Both tap and other
W_WaterAfford	66% Declined 27% Same 6% Improved	43% Declined 53% Same 2% Improved

Cluster narrative (Water variables)

Cluster 1: 'Inside facilities but decreased affordability' – This cluster is far larger than Cluster 2 and includes all the Pniel households, two-thirds of Lanquedoc households, and 71% of Noordhoek households. Almost all the households have taps inside the dwelling for drinking water and other uses, with one third also using other water sources for household uses. Also, all the households have their own flush toilet. The water demand is met in 90% of households. The affordability of water has declined in two-thirds of the households.

Cluster 2: 'Outside facilities but lower decrease in affordability' – One third of Lanquedoc households and 29% of Noordhoek households are in this cluster. Drinking water and water for household use are accessed from an outside tap in most cases. Most households (60%) do not have their own flush toilet but use either communal flush toilets or other types, e.g. bucket toilet. Water demand is met in only 60% of households. The affordability of water has declined but by less than in Cluster 1 and in half the households it has remained the same.

4.4.5 Energy variables

For energy, the MCA plot (Fig. 33) shows that Lanquedoc has high variability more in the first dimension, whereas Pniel and Noordhoek have high variability in more in the second dimension.

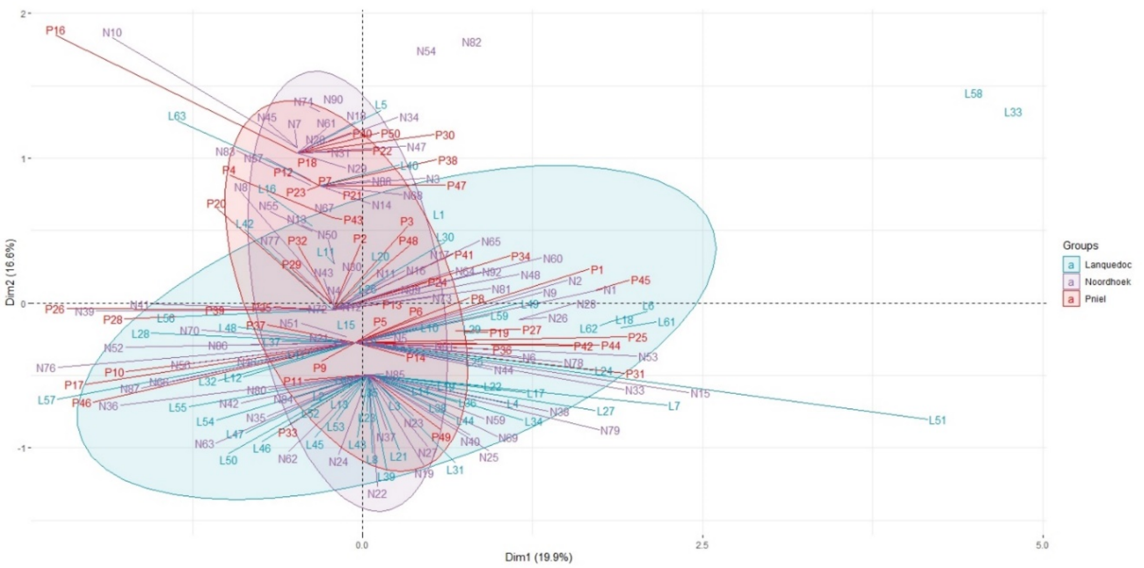


Figure 33 Multiple Correspondence Analysis (MCA) plot showing the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 5 variables (9 columns) relating to energy information. The communities are colour coded and ellipses indicate the extent of variation within the community and overlap with others. Dim = dimension (with % explained variance given in parenthesis), L = Lanquedoc, N= Noordhoek, P = Pniel.

The factor plot (Fig. 34) shows three clusters, with no overlap. The significant variables (Fig. 81 in Appendix 3) were analysed and the results presented in Table 22 in decreasing order of statistical significance.

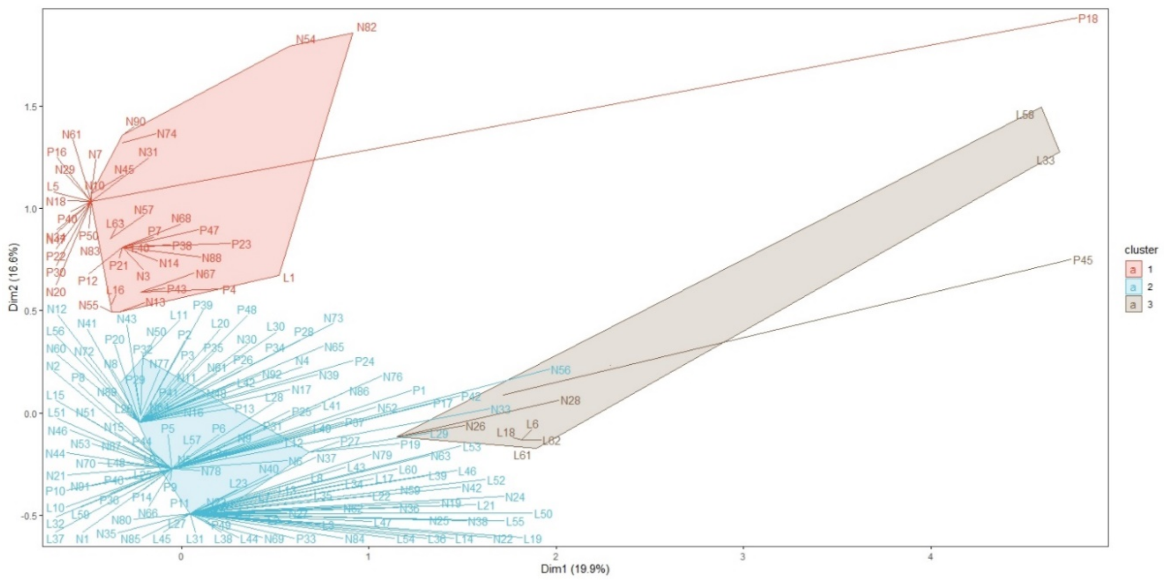


Figure 34 Factor plot visualising the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 5 variables (9 columns) relating to household level contextual information as well as the water-energy-food nexus. The first two dimensions are plotted (dim 1 and 2), with a cumulative explained variance of 36.5%. Clusters of households, and their minimum bounding geometries, are coloured according to three groups which were selected using the corresponding dendrogram and each household is labelled according to its unique ID: L = Lanquedoc, N= Noordhoek, P = Pniel.

Table 22 Results of Level 4 analysis (Berg communities) based on variables in the energy category. E= variables relate to energy. For the full names of the variables, refer to Appendix 3.

Variable	**Cluster 1** 14/49=Pniel 5/63=Lanquedoc 23/87=Noordhoek **Total: 42**	**Cluster 2** 34/49=Pniel 52/63=Lanquedoc 62/87=Noordhoek **Total: 148**	**Cluster 3** 1/49=Pniel 6/63=Lanquedoc 2/87=Noordhoek **Total: 9**
E_EnSou_Cooking_All	88% Gas 7% Gas & Electricity 5% Electricity	1% Gas 99% Electricity	78% Wood 22% Wood & Electricity
E_EnSou_All_Gas	98% Yes	99% No	100% No
E_EnSou_All_Wood	98% No	98% No	100% Yes
E_EnSou_All_Elec	100% Yes	99% Yes	78% Yes
E_EnSou_All_Candl	95% No	100% No	78% Yes
E_EnergyAccess	45% Declined 38% Same 17% Improved	25% Declined 70% Same 5% Improved	100% Same
E_EnergyAfford	83% Declined 17% Same	59% Declined 38% Same 3% Improved	44% Declined 44% Same 11% Improved

Cluster narrative (Energy variables)

Cluster 1: 'Gas and electricity' – This cluster includes just under one third of households in Pniel and Noordhoek, but only a handful of households in Lanquedoc. Almost all the households report using gas, or a combination of gas and electricity, for cooking. The primary source of energy is electricity. Most of the households have experienced a decline in energy affordability, with half of them experienced a decline in energy access. These trends are likely to have driven their high use of gas.

Cluster 2: 'Electricity – The largest cluster by far, it includes two thirds of Pniel and Noordhoek households, and 83% of households in Lanquedoc. Electricity is the primary source of energy and cooking is also done using electricity. The affordability of energy has declined in most households although the proportion is not as high as in Cluster 1. Most of the other households reported that affordability remained the same. Access to energy has remained the same in most households, with one quarter of households reporting a decline.

Cluster 3: 'Wood and electricity' – This is a small cluster confined to a large degree to Lanquedoc. Although most households have electricity as their main source of energy (but notably not all, with two households not having a connection), most households use wood for cooking, and some use a combination of wood and electricity. Less than half of households have experienced a decline in energy affordability, and for most of the other half it has remained the same. Energy access has remained the same in all the households.

4.4.6 *Food variables*

For food, the MCA plot (Fig. 35) shows that Lanquedoc and Noordhoek have high variability mostly in the first dimension, whereas Pniel has much lower variability than the other two sites in both dimensions.

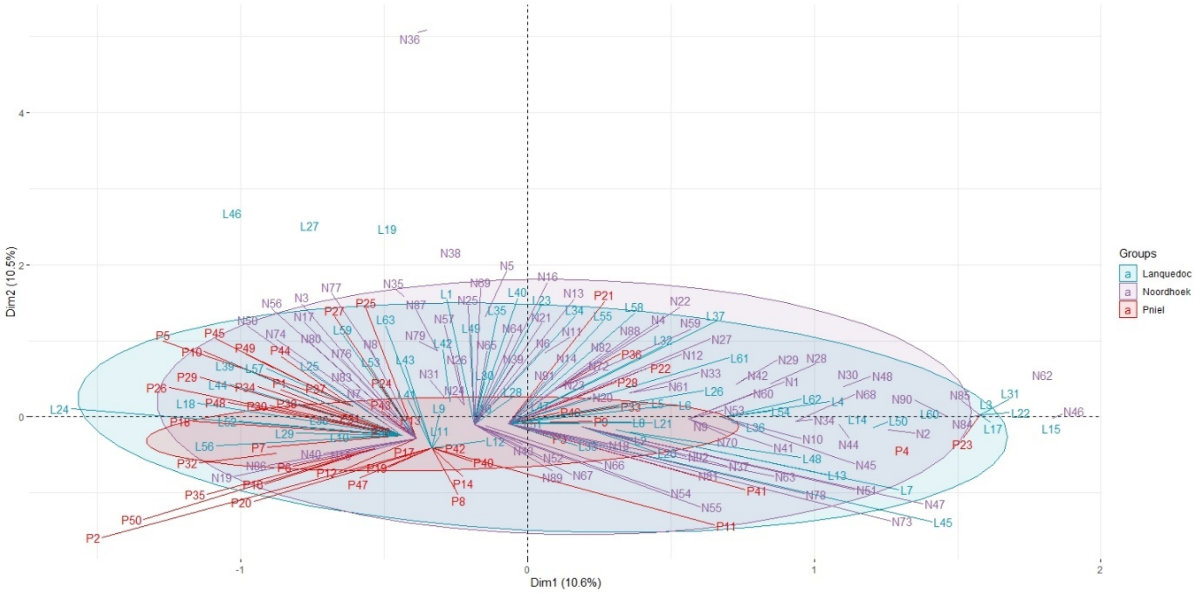


Figure 35 Multiple Correspondence Analysis (MCA) plot showing the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 8 variables (9 columns) relating to food information. The communities are colour coded and ellipses indicate the extent of variation within the community and overlap with others. Dim = dimension (with % explained variance given in parenthesis), L = Lanquedoc, N= Noordhoek, P = Pniel.

The factor plot (Fig. 36) shows four clusters, with no overlap. Cluster 2 consists of only one household that is quite distinct from the other three clusters. The significant variables (Fig. 82 in Appendix 3) were analysed and the results presented in Table 23 in decreasing order of statistical significance.

Cluster narrative (Food variables)

Cluster 1 – ‘the fortunate few’: Ten households in Lanquedoc and Noordhoek form this cluster. Most of the households report an improvement in food diversity, and half of them report an improvement in food affordability over the last few years. Expenditure on food is generally less than 50% of income with significant numbers of households spending less than 25% on food. One fifth of the households engage in fishing to supplement the household’s food needs.

Cluster 2 – ‘grow my own’: The only household in this cluster (in Noordhoek) is characterised by reporting that it obtains its weekly food needs from its own food garden. It also supplements its food needs through fishing. This household also reported an improvement in food affordability but a decline in food diversity.

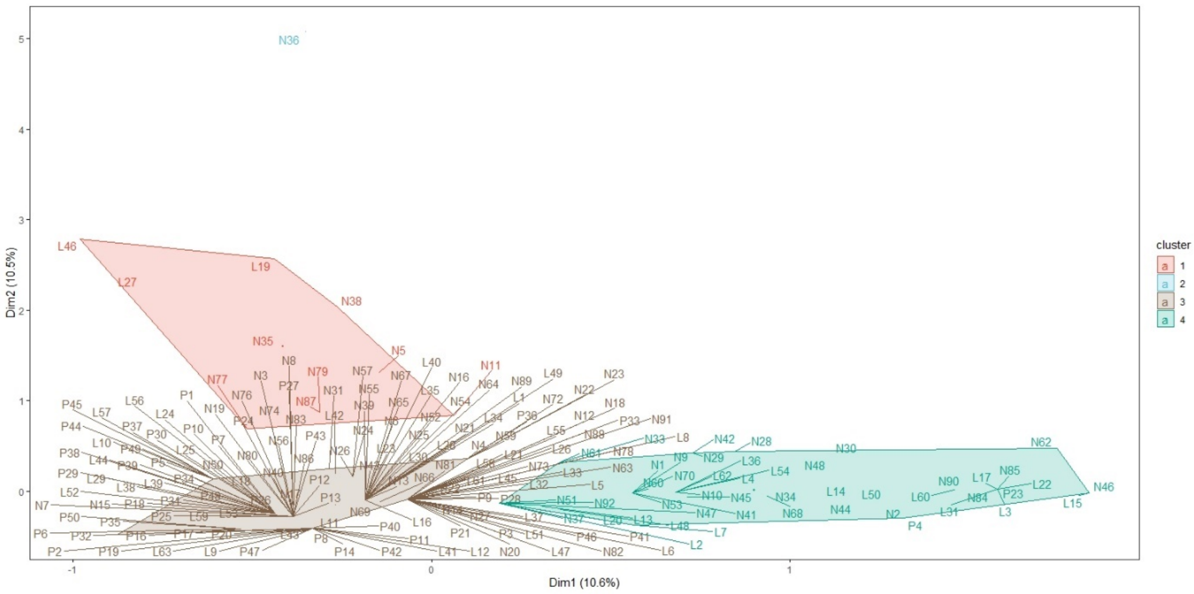


Figure 36 Factor plot visualising the relationships between households from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households) in terms of 8 variables (9 columns) relating to food information. The first two dimensions are plotted (dim 1 and 2), with a cumulative explained variance of 21.1%. Clusters of households, and their minimum bounding geometries, are coloured according to four groups which were selected using the corresponding dendrogram and each household is labelled according to its unique ID: L = Lanquedoc, N= Noordhoek, P = Pniel.

Cluster 3 – 'declining food security': This is the largest cluster and includes almost all the Pniel households, two thirds of households in Lanquedoc and 60% of those in Noordhoek. Almost all the households have experienced a decline in food diversity and food affordability. Food expenditure as a percentage of household income varies widely with most households spending between 25 and 75% of their income on food. A small number of households engage in fishing for food.

Cluster 4 – 'the stable minority': This cluster includes one quarter of Lanquedoc households and one third of Noordhoek households. The cluster is characterized by stability of food diversity in three quarters of the households, and stability of food affordability in 40% of the households. A higher proportion of households (compared to cluster 3) spend less than 25% of their income on food and few households spend more than 50%. Several of the households engage in fishing for food.

Table 23 Results of Level 4 analysis (Berg communities) based on variables in the food category. F = variables relate to food. For the full names of the variables, refer to Appendix 3.

Variable	Cluster 1 0/49=Pniel 3/63=Lanquedoc 7/87=Noordhoek Total: 10	Cluster 2 0/49=Pniel 0/63=Lanquedoc 1/87=Noordhoek Total: 1	Cluster 3 47/49=Pniel 43/63=Lanquedoc 51/87=Noordhoek Total: 141	Cluster 4 2/49=Pniel 17/63=Lanquedoc 28/87=Noordhoek Total: 47
F_FoodDivers	20% Declined 80% Improved	100% Declined	99% Declined	26% Declined 74% Same
F_FoodLoca_OwnGarden	100% No	100% Yes	100% No	100% No
F_Afford	50% Declined 50% Improved	100% Improved	99% Declined	60% Declined 40% Same
F_FoodExpend	60% <25% 20% <50% 10% <75% 10% <100%	100% <50%	18% <25% 45% <50% 28% <75% 7% <100%	57% <25% 34% <50% 9% <75%
F_Fishing	20% Yes 80% No	100% Yes	8% Yes 92% No	17% Yes 83% No

4.5 Level 5: In-depth quantitative comparison of two communities within the Keiskamma catchment[12]

This section provides a summary of the findings of this study in the Keiskamma catchment communities, namely, Hamburg and Melani. Full results are available in Ningi (2020). Here, we present only the summary results for the three indices for water, energy and food security, their determinants, and the correlations between the three indices.

4.5.1 Water Poverty Index and factors affecting water security

The Water Poverty Index (WPI) for Hamburg and Melani was on average 16 and 15.7, respectively, implying a high degree of water insecurity, mainly caused by poor water availability and time spent on water collection (Table 24). However, for most people from both communities, the limited water they have access to is generally clean and safe for drinking. The water poverty challenge for the two communities is, therefore, more related to technical and institutional challenges.

[12] This section is a contribution of Thulani Ningi and forms part of his Masters thesis.

Table 24 Water Poverty Index (WPI) for Melani and Hamburg communities.

Community	Water availability (%)	Access to clean & safe drinking water (%)	Index of time spent in water collection	WPI
Weights	0.5	0.25	0.25	
Melani	24	74	33	15.7
Hamburg	17	86	28	16

Table 25 presents the results of the factors influencing water security status in the two communities. These were estimated using a Tobit regression model with WPI as the dependent variable. The factors 'paying for water', 'type of toilet used', and 'time spent collecting water' significantly influenced the water security status of households. The other nine variables were insignificant.

The more time spent by households collecting water, the more likely they were to be water insecure. In the study area, water in community taps tends to be unavailable for long periods in a year, forcing the households to walk long distances to, e.g. rivers, dams and boreholes looking for water. Time taken to look for water from distant places forces households to reduce water consumption as a saving mechanism, negatively affecting their water security. A comparable study by Tussupova (2016) noted that households in rural areas use public sources of water and must walk long distances and spend a lot of time collecting water.

Increases in payment for water were associated with increased household water security. This implies that households with the capacity to pay for water have lower chances of running out of water. This might be explained by the fact that households with the capacity to pay for water have access to different sources of purchased water making them water-secure compared to households with limited capacity to pay for water. Because water is a very important economic good requiring consumers to carry the economic cost, several scholars have claimed that households are willing to pay for water to increase water security in terms of reliability and good quality water (Kujinga et al., 2014; Dlamini, 2015; Pinto et al., 2018).

Increases in 'type of toilet used' (where flush toilet = 1 and non-flush outside toilet = 0) were also associated with increased household water security. This therefore implies that the more households use flush toilets than using outside pit toilets, the more their chances are of increasing their water security. This might be explained by the fact that households with flush toilets have access to clean water for flushing and have access to clean sanitation.

Table 25 Determinants of water security status: Tobit regression model results.

Variables	Estimated Co-efficient	Std. Err.	*p* significance level
Age of the HH head	0.00008	0.0123	0.994
Marital	0.3890	0.312	0.215
Household size	-0.0851	0.066	0.199
Paying for water	0.7767	0.371	0.038**
Employment status	-0.6819	0.737	0.356
Race of the HH head	-2.9296	1.674	0.081
Type of toilet used	1.2644	0.624	0.044**
Water infrastructure	0.5168	0.309	0.096
Farming	0.3846	0.308	0.214
Time spent collecting	-0.5081	0.114	0.000***
Primary education	0.1577	0.463	0.734
Secondary education	0.6709	0.357	0.062
Tertiary education	0.2659	0.639	0.678
Income: Salary	0.3356	0.827	0.685
Income: Business	1.2885	0.711	0.071
Income: Remittances	2.0992	1.130	0.065
Constant	13.4737	0.891	0.000***
	Model summary		
Number of observations = 283 Pseudo R^2 = 0.36 Log likelihood = -651.786 Significance of LR X^2 = (49.22) 0.000***			

Note *** and ** shows the level of significance at 1% and 5%, respectively.

4.5.2 Multidimensional Energy Poverty Index and factors affecting energy security

The average Multidimensional Energy Poverty Index (MEPI) for Hamburg and Melani households was 17 and 16, respectively, which implies low energy poverty (Table 26). This may be explained by high levels of access to electricity and additional measures of energy.

Table 26 Multidimensional Energy Poverty Index (MEPI) for Melani and Hamburg communities.

Community	MEPI (%)	The intensity of energy deprivation	Access to additional measures of energy (%)	Access to electrical stove for cooking (%)	Access to electricity (%)
Hamburg	17	0.25	31.2%	72.5%	95.1%
Melani	16	0.21	40.1%	89.4%	98.6%

Table 27 presents the results of the factors influencing energy security status in the two communities. These were estimated using a Tobit regression model with the MEPI as the dependent variable. The factors marital status of the household head, household size, affordability of electricity, and income from agriculture significantly influenced the energy security status of households. The other variables were insignificant.

Marital status had a positive relationship with MEPI, meaning that households with a married head of household had higher chances of being energy insecure than households with an unmarried head. It is likely that married household heads have more expenses to cover with their income, thus reducing their energy security status (Tchereni et al., 2013).

The findings also suggest that the bigger the household size the more the household is likely to be energy insecure. This could be supported by the fact that the more people living in one household, the more energy is consumed in household activities like cooking, bathing, boiling water for tea, etc. According to Ismail and Khembo (2015), when the number of the household members increases, a fixed household budget must be distributed among more people causing energy poverty.

Households that can afford to pay electricity bills are more likely to be energy secure (Table 27). Affordability gives households purchasing power to consider a wide variety of energy sources, thereby increasing their energy security compared to households with lower affordability. Njiru and Letema (2018) indicated that poor households in rural areas without access to affordable energy tend to purchase expensive and unhealthy forms of energy, thereby promoting energy poverty. Ismail and Khembo (2015) claimed that in most rural areas, low-income households cannot afford electricity provided by the national grid, though they do have access to it.

Households that move from other income sources to agriculture are more likely to be energy secure. This might be explained by the fact that agriculture (for example keeping cattle) is a better income source than other income sources in the study area. Income from agriculture can improve the energy purchasing power of rural households, thereby making them more energy secure than other households who depend on other income sources. According to Kilian (2008), households with low salaries are constrained by the high energy prices which lower their purchasing power due to high energy bills, therefore leaving them energy poor. Also, Truen and Chisadza (2016) stated that having more income streams may also contribute to high-income levels, thereby improving the purchasing power for households which will enable them to pay for electricity bills.

Table 27 Determinants of energy security status: Tobit regression model results.

Variables	Estimated coefficients	Std. Err.	*p* significance level
Income of the household head	-0.647	0.733	0.378
Marital status	4.040	1.412	0.005***
HH-size	0.748	0.298	0.013**
Employment status	3.733	3.345	0.265
Race of the household head	9.989	6.995	0.154
Electricity affordability	-3.043	0.840	0.000***
Age of the household head	-0.067	0.0515	0.189
Credit access	2.357	2.141	0.272
Income: Agriculture	-19.934	8.750	0.024**
Income: Salary	-9.267	5.060	0.068
Income: Business	-7.754	4.588	0.092
Income: Social grant	-4.664	3.620	0.199
Income: Remittances	-6.817	6.090	0.264
Constant	25.209	4.334	0.000
	Model summary		
Number of observations = 283 Pseudo R^2 = 0.0163 Log likelihood = -1077.969 Significance of LR X^2 = (35.63) 0.007***			

Note *** and ** shows the level of significance at 1% and 5%, respectively.

4.5.3 Household Food Insecurity Access Scale and factors affecting food security

Table 28 shows that 39.7% and 34.7% of households in Melani and Hamburg, respectively, were food secure. Most of the households in both communities were either food secure or mildly food insecure. Only 5.7% and 3.5% of households in Melani and Hamburg, respectively, were severely food insecure.

Table 28 Household Food Insecurity Access Scale (HFIAS) for Melani and Hamburg communities.

Household Food Insecurity Access Scale				
	Melani		**Hamburg**	
	Frequency	Percent	Frequency	Percent
Food secure	56	39.7 %	49	34.5 %
Mildly food insecure	47	33.3 %	61	43.0 %
Moderately food insecure	30	21.3 %	27	19.0 %
Severely food insecure	8	5.7 %	5	3.5 %
Total	141	100 %	142	100 %

Table 29 presents the results of factors affecting the food security status of the two communities using ordinal logit regression. The Household Food Insecurity Access Scale (HFIAS) was used as the dependent variable on the regression ordered as follows: 1 = food secure: 2 = mildly food insecure: 3 = moderately food insecure: 4 = severely food insecure. The implication is that a higher net value indicates high food insecurity and *vice versa*. The factors gender of the household head, household size, the MEPI, access to credit, farming, land ownership and affordability of water significantly influenced the food security status of households. The other variables were insignificant. The HFIAS reveals seven relevant themes/indicators:

Gender of household head: The results indicate that female-headed households are more likely to be food insecure than male-headed households. This may be explained by the fact that in rural areas, male-biased economic, cultural and community norms limit women from having additional incomes or being involved in farming to reduce food insecurity. According to FAO (2017), female-headed households are more likely to be food insecure as compared to male-headed households, especially in rural areas (McDonald and Ruiters, 2012).

Household size: As the household size increases, the probability of high food insecurity in the household rises. Larger household sizes mean more stomachs to feed and a higher monthly budget for food. Similar results were observed by Maziya et al. (2017) arguing that household size is among the most important factors influencing household food insecurity because, as the number of household members increases so does the number of people to feed for a fixed income, thus reducing per capita food consumption. This was also highlighted by Sekhampu (2013) who claimed that as the household size increases the expenditure and competition for food or limited resources in the household also increase.

Access to credit: The results suggest that the more that households have access to credit, the higher the chances of being food insecure. Access to credit tempts many rural households to borrow; however, this puts them in a trap of high-interest rates they are unable to pay because of their poor rural income sources. As a result, those with access to credit end up losing a bigger share of the household income towards loan repayment, which compromises the household food budget. Similar findings were shared by Maziya et al. (2017), namely, that households who use credit have high chances of becoming food insecure compared to those who do not use credit. They argued that households with credit access more often use the credit on other non-food, non-income generating items (clothing, cars, phone bills, etc.).

Multidimensional Energy Poverty Index: The results indicate a positive association between the MEPI and the HFIAS. This suggest that increasing the energy poverty of households will increase their HFIAS, making them more food insecure. This could be explained by the fact that for food to be edible and digestible, energy is required for processing. Energy poverty will therefore negatively influence food choices, cooking and eating habits, often targeting food groups and cooking habits that do not require more energy, and thus more often compromising dietary diversity and quality. Similar findings were observed by Sola et al. (2016) who noted that energy access increases the level of household food security in rural areas through dietary choices and cooking practices. According to Bogdanski (2012), with limited energy access, food security cannot be achieved mainly because food must be cooked for it to be palatable and safe to consume.

Farming: Farming lowers the probability of high food insecurity in the household. This might be explained by the fact that farming activities contribute to household food availability, diversity and intake as money is not always available to buy nutritious food, especially in rural areas. Khan et al. (2009) found similar results which indicated that farming in rural areas is one of the major factors which contribute to the increase in food availability. According to Apanovich and Mazur (2018), most of the population in rural areas is dependent on subsistence farming thus making farming central to food security.

Land ownership: Land ownership decreases the probability of high food insecurity for the household. Households with land ownership are more likely to practice farming that provides a variety of food options compared to households without land ownership. A study conducted by Nasrin and Uddin (2011) found similar results which indicated that households who have secure land rights are more food secure than those who have no land ownership. Several scholars (Ghebru and Holden 2013; Mueller et al., 2014; Nkonki et al., 2019) have attested that land ownership has a positive and significant association with food security.

Affordability to pay for water: With increasing ability to pay for water comes a decreased probability of high food insecurity in a household. Households that can afford to pay for water are normally water-secure, capable of conducting different agricultural enterprises, and able to choose and prepare balanced foods, as opposed to water insecure households that may have limited food options and agricultural enterprises that do not require much water. Similar findings were observed in Figueres et al. (2013) who indicated that water is required for food security.

Table 29 Determinants of food security status: Ordinal logit regression results.

Variables	Estimate	Std. Error	Sig.
Gender of the household head	0.535	0.267	0.045**
Household size	0.261	0.123	0.033**
Education status	-0.234	0.146	0.109
Source of income	0.264	0.188	0.161
Employment status	0.215	0.488	0.660
WPI	0.110	0.044	0.062
MEPI	0.048	0.011	0.000***
Credit access	0.762	0.379	0.045**
Farming	-0.658	0.252	0.009***
Land ownership	-0.215	0.488	0.015**
Affordability to pay for water	-0.760	0.292	0.009***
	Model summary		
Number of Obs = 283 **Chi-square (df) (Sig) = 76.77** **(-2) Log Likelihood = 615.940** **Nagelkerke R^2 = 0. 211**			

Note *** and ** shows the level of significance at 1% and 5%, respectively.

4.5.4 Implications of water and energy security on household food security

This section presents the results of the bivariate correlation analysis (Table 30). The analysis sought to measure the association between water, energy and food insecurity. The study made use of a non-parametric test (Spearman's rho) to measure the degree of association between water, energy and food insecurity.

The results reveal a statistically significant (p-value = 0.023) weak positive correlation (coefficient = 0.135) between the household water poverty index (WPI) and the household food insecurity access scale (HFIAS). This suggests that, as household water security increases, there is a weak increase in the household's food insecurity. In cash economies like rural South Africa where subsistence agriculture is insignificant and quality water is purchased, livelihood variables like water, energy and food compete for the ‘household's pocket’ (household income). Thus, overall, the cooking and food selection benefits associated with water security towards influencing food security seem to be suppressed by the income substitution effect; where a unit allocation of household income towards water will yield more than a unit decrease in food availability for the household, assuming all other variables remain constant. Against this background, an increase in water security would put pressure on the food budget of the household. The observed positive correlation suggests pressure on household income negatively affecting household food security as the household tries to improve water security. Comparable previous studies reported that because of the decline in farming activities in rural areas, soon water security will not have a significant hold on food availability (Simbi and Aliber, 2000; Isaacs et al., 2017).

The results also reveal a statistically significant (p-value = 0.000) weak positive correlation (coefficient = 0.315) between household energy poverty (MEPI) and the Household Food Insecurity Access Scale (HFIAS). This suggests that, as household energy poverty increases, there is a weak increase in household food insecurity. Food preparation requires a significant amount of energy at the household level for the food to be palatable and edible (WFP, 2019). An increase in energy poverty is likely to be associated with the selection of food groups and food choices that do not require a lot of energy. Unfortunately, these food choices and food groups, commonly called ‘junk food’, more often than not compromise dietary diversity and food quality. According to Bogdanski (2012) and von Borman and Gulati (2014), where there is limited access to energy, food security cannot be achieved mainly because food has to be cooked for it to be nutritious, palatable and safe to consume.

The results of this study provide the following insights:

1. There is a high level of water scarcity in the sites (Hamburg and Melani), although it is interesting to note the high number of households with access to clean and safe water to drink. In both communities, water availability and time taken to collect water are the major issues contributing to water insecurity, and represent technical and institutional barriers. The water stress in these communities might be influenced by a lack of water resources (e.g. rivers, dams, boreholes, etc.). Thus, efforts to increase household water security should focus on addressing water availability and minimizing the time taken to collect water.

Table 30 Correlation matrix between water, energy and food insecurity.

			HFIAS	WPI	MEPI
Spearman's rho	HFIAS	Correlation coefficient	1.000	0.135*	0.315*
		Sig. (2-tailed)	.	0.023	0.000
		N	283	283	283
	WPI	Correlation coefficient	0.135*	1.000	0.077
		Sig. (2-tailed)	0.023	.	0.198
		N	283	283	283
	MEPI	Correlation coefficient	0.315**	0.077	1.000
		Sig. (2-tailed)	0.000	0.198	.
		N	283	283	283
***. Correlation is significant at the 0.05 level (2-tailed).**					
****. Correlation is significant at the 0.01 level (2-tailed)**					

2. Energy security in the sites is not so much of an issue as the MEPI in both communities was very low, indicating very low energy poverty. This could be explained by the fact that most households had access to electricity. However, household access to additional sources of energy was relatively low. This may seriously affect their energy security in the case of interruptions of electricity. To avoid overreliance on one source (ESKOM electricity), efforts targeting improvement in additional sources of energy will positively influence household energy security.
3. Most of the households in both communities were classified as food secure or mildly food insecure, while a minority were classified as moderately or severely food insecure.
4. Household water security was mainly affected by economic and institutional factors. On the other hand, household energy security was mainly affected by socio-economic factors, while food security was mainly affected by socio-economic and institutional factors. The water, energy and food nexus at household level may therefore be

positively enhanced by a series of socio-economic and institutional factors as highlighted in the above three models.

5. Livelihood variables such as water, energy and food compete for the household's income. In cash communities where water, energy and food are mostly purchased, such as in Hamburg and Melani, households trying to improve one variable (water) may negatively affect their food security through the income substitution effect. On the other hand, energy poverty also drives food insecurity through the food substitution effect. Against this background, the study argues that, depending on household and community dynamics, the water, energy and food nexus is not direct and obvious but is rather complex, area-specific and household-specific.

4.5.5 Conclusion

The study concludes that water stress in the study area is a serious issue mainly caused by unavailability of water resources and time taken to collect water. With reference to energy poverty, the study noted that a majority of the respondents were energy secure; however, access to additional measures of energy was relatively low which may affect their energy security if the main source (ESKOM electricity) is interrupted. With regard to the third dimension, food, it can be noted that most of the respondents were food secure.

The study also concludes that certain factors increase household water security (use of a flush toilet, and paying for water), while other factors reduce household water security (time spent collecting water). With reference to energy poverty, certain factors increase household energy poverty (female household head, and larger household size) while other factors reduce household energy poverty (source of income from agriculture, and affording to pay for energy). Lastly, the study concludes that household food insecurity is increased by female household head, larger household size, greater energy poverty, and access to credit; and food insecurity is reduced by household farming activities, land ownership, and affording to pay for water.

The study further concludes that water security is weakly associated with food insecurity, and energy insecurity is weakly associated with food insecurity. These findings suggest that addressing water security in areas where water is purchased may negatively affect households' food security through the income substitution effect, while an increase in energy poverty can also compromise households' food security. Thus, trying to address water security in a society where water is purchased and household income levels are low, may negatively affect household food security, since the two (water and food bills) compete for the household income. Attempting to address water security in such communities without addressing income may fail to yield the expected water-food security improvement. Improving access to free water sources and reducing distances travelled for collection of water will improve water security without negatively affecting household food security. A decline in energy security, on the other hand, triggers increased household food insecurity through compromised food selection choices and change in cooking habits to accommodate low energy availability. Efforts to improve energy-food security in such low-income communities should therefore focus on providing access to additional energy sources that are not expensive so as to avoid the income substitution effect. The water-energy-food security nexus at household level is not obvious and direct, but rather complex, depending on several socio-economic and location-based geo-political factors worth understanding.

4.6 Integrating livelihood assets and WEF through indices

Drawing on available variables from the Census and the case studies, an index was developed for each of five livelihoods capitals for each community: financial, physical, human, social and natural. The summary spider plot highlights the complex interactions between catchment-specific physical, human and natural capitals, site-specific social capital, and ubiquitously constrained financial capital in these communities (Fig. 37). Overall, the Keiskamma communities showed a slightly lower livelihood-WEF index, owing to their lower scores on financial, physical and human capital. The combination of capitals resulted in similar overall indices for the other five communities (Table 31). Further discussion of the results can be found in section 7.2.

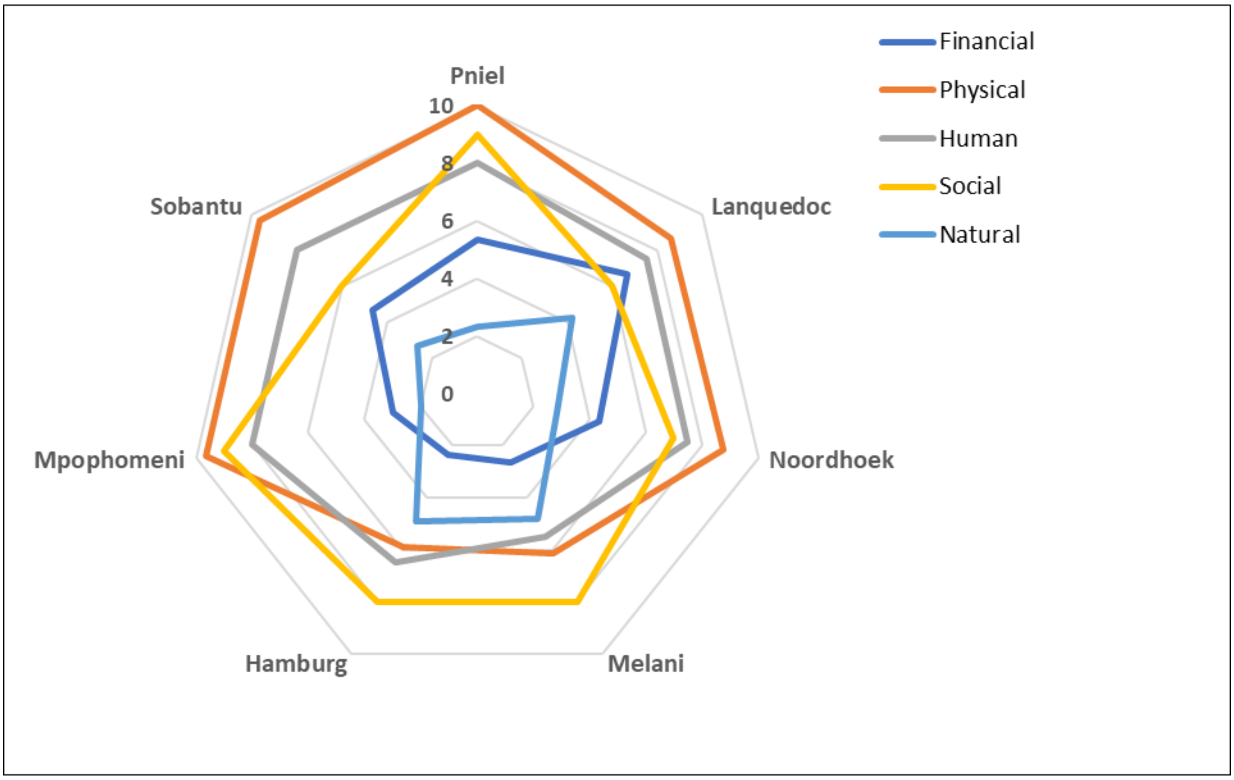


Figure 37 Summary of WEF-related livelihoods capitals across the seven sites based on an index developed for each capital.

Table 31 Summary of livelihoods capitals across the seven sites.

	Financial	Physical	Human	Social	Natural	Overall
Pniel	yellow	blue	green	blue	orange	green
Lanquedoc	green	green	yellow	orange	orange	green
Noordhoek	yellow	green	yellow	yellow	orange	green
Sobantu	yellow	blue	green	orange	orange	green
Mpophomeni	orange	blue	green	blue	red	green
Hamburg	orange	red	orange	green	yellow	yellow
Melani	orange	orange	red	green	yellow	yellow

Colour coding represents the value of the following indices. Financial and natural index: 1-2=red; 2-4=orange; 4-6=yellow; 6-8=green; 8-10=blue. Physical, human and social index: 5-6=red; 6-7=orange; 7-8=yellow; 8-9=green; 9-10=blue.

When comparing our method with that of Nhamo et al. (2019), also for South Africa, certain similarities can be seen. Both methods incorporate indicators relating to availability, accessibility, affordability and stability (see 'indicator pillars' in Nhamo et al., 2019). These researchers used multi-criteria decision-making (MCDM) to then identify a group of six indicators analytically, to be used in country-level assessments. Nhamo et al. (2019:12) point out that certain considerations must be made before applying the model at different scales or different purposes: "The indicators defined for this study are those that measure the security of water, energy and food at country level. Although these are valid for this study and at country level, they can be adjusted for other purposes, but using the same procedure. The focus on the security of the three WEF resources was based on southern Africa regional priorities, but priorities may differ across scale and context, thus the indicators may be adjusted to suit each context and region. For example, at household level different indicators can be used depending on the objectives."

Our study, while not analytically premised, developed a methodology from the ground up, based on a rich set of quantitative and qualitative results from the seven case studies in three diverse catchments of South Africa. When comparing our results with Nhamo et al. (2019) we do indeed see similarities in some respects (e.g. availability and accessibility of WEF resources), but not in others (e.g. WEF 'productivity', which is more of a national concern). Further, by interlinking the five livelihood capitals, we showed that consideration of the natural environment, of local infrastructure and its sufficiency and reliability (service delivery), and of human and social capital are essential at the household level. Jaka (2019) have provided grounded research evidence in this regard for South African and Zimbabwean rural communities. This emerging understanding is an improvement on the often demand-consumption-led ('footprinting') conceptual frameworks and analytical methods, e.g. Hussien et al. (2017) for household level WEF nexus analysis. The Hussien et al. (2017) approach is limited to the accounting of resource flows and does not take socio-ecological and other livelihood factors into consideration. Other published research appears to have stalled at the conceptual level, e.g. Biggs et al. (2015), and has yet to be developed into an operationalised method.

An alternative method to the one we tested could have been to use the indices described in section 3.2.3 (Level 5), namely, the Water Poverty Index, the Multidimensional Energy Poverty Index, and the Household Food Insecurity Access Scale, to calculate a combined WEF security index at household level. This could be tested in future research.

Limitations to our method lie in the valuation of natural capital, which decreases in livelihood-related importance as households and communities become more urbanised in emerging economies (i.e. is this decrease a positive or negative trend?). The role of human and social capital requires further investigation in the livelihood-WEF context. Many references to health emerged in this study, but it was not explicitly studied. The health linkages within the WEF nexus were highlighted by Mabhaudhi et al. (2019). Importantly, the impact of political economy and governance challenges at local scale may be more important than any direct interlinkages between livelihood capitals and WEF insecurity. We have touched on this in the study, but further research is required to integrate this factor into an index-based assessment framework (if this is possible).

CHAPTER 5: RESULTS FROM CASE STUDIES – THE QUALITATIVE LENS

5.1 Mapping WEF resource flows at community level

By exploring the systems that supply WEF resources to the households through WEF resource mapping, expert interviews, and learning journeys, the nexus became more apparent, as did the intersection with livelihoods. For example, in the rural setting of Hamburg where an intermittent water supply impacts on local subsistence and small-scale food production and tourism; and electricity load shedding impacts on bulk water supply. The resource mapping process provided also an excellent platform for deepening the knowledge exchanges between researchers and non-academic actors, as well as deepening the CRAs' exposure to 'nexus thinking' in relation to the local WEF resource supply chains.

5.1.1 Velddrif (Noordhoek)[13]

Results from the census data and the household questionnaire conducted in Noordhoek provided an initial assessment of the livelihoods and household WEF securities. They revealed a high level of basic service provision by the municipality of both water and electricity. This was complemented by an emerging picture of household reliance on supermarkets and smaller retail outlets for food, with limited evidence of food gardens and fishing. This was surprising given that Velddrif is known as a 'fishing village'. However, the biodiversity-based restrictions on fishing in the estuary and the presence of a large fish processing factory serviced by a fleet of trawlers, may be some of the factors why people have moved away from fishing as an income generating activity. The households, therefore, have little contact with the primary provision of the WEF resources and thus fulfil the role of being consumers at the end of bulk resource supply chains linked to retail, water and electricity. The household questionnaire identified the fisheries and retail sectors, both situated in central Velddrif, as key employers in the area. Upon further investigation through the expert interviews and resource mapping, both were identified as major electricity (in the case of the retailer) and electricity and water (in the case of the fish processing plant) users in the area. This pointed to an intersection between some of the bulk consumers of water and energy resources and livelihoods which is of interest in terms of local economic development. An additional point to note here is that both employers are involved in a sector related to food – a slightly removed, but significant link to the WEF nexus.

5.1.1.1 Water supply system

The water supply system that services Velddrif forms part of the WCWSS. The region depends primarily on this system and the Berg River. Ground water is also used but to a limited extent due its high salinity in the region (Seyler and Millson, 2015). In contrast to the upper Berg catchment, the middle and lower reaches of the Berg catchment experience relatively low

[13] This section is a contribution of Penny Price and forms part of her Masters thesis.

rainfall, with mean annual rainfall at Langebaanweg weather station being 278 mm/annum (CSIR, 2019). In this semi-arid context, competition for water resources is high, with the river supporting one of the country's major metros, namely Cape Town, a significant agricultural sector including wheat, potatoes and grapes, as well as some large scale manufacturing plants such as Saldanha Steel, Saldanha Industrial Development Zone (IDZ), fish processing factories and cement factories. These competing demands place a large strain on the Berg River and its aquatic ecosystems and services.

The water supply system was initially explored through expert interviews with key actors in the water supply chain, including officials from Bergrivier and West Coast District municipalities. The West Coast District Municipality (WCDM) is the bulk Water Services Provider in the area, servicing 21 towns in three local municipalities, as well as 7 rural schemes. The WCDM extracts water from the Misverstand Dam (Fig. 38) which is pumped to the Withoogte Water Purification Works, where it is augmented with water pumped from boreholes in the Langebaanweg aquifer (Fig. 38), treated to potable standard and pumped to reservoirs in Velddrif (Fig. 38). If the water level in Misverstand Dam is above 80%, the WCDM stops pumping the Langebaan aquifer boreholes. The Bergrivier Local Municipality (BRM) pumps that water through its own water reticulation system, which it manages, to supply the residents of Velddrif.

During the drought (2015-2018), the Misverstand Dam dried up and water was released from the Berg River to Voëlvlei Dam, and then to the Misverstand Dam. This was reported as an excellent example of intergovernmental cooperation involving the DWS, the Western Cape Government, WCDM and various local municipalities including BRM. This was done twice. The first time the water did not reach Misverstand Dam as it was all taken up by desperate farmers. A local fish processing factory put in its own desalination plant during the drought as the BRM could no longer supply the required quantities due to the water restrictions. This significantly reduced the BRM's income from water sales. Prior to the drought, the fish factory was using about half of the water allocated to Velddrif before installing the desalination plant. Considering the existing water demands in the area, the new Saldanha IDZ development in the area is conducting its own feasibility study for identifying additional sources. Saldanha Local Municipality has also installed deeper boreholes into the Langebaanweg aquifer, but the WCDM does not have budget to take similar measures.

The Withoogte Plant can run for four days without ESKOM electricity supply as it has six backup generators. There were also energy implications in the drought. The water purification plant usually pumps off-peak to secure a cheaper rate for the electricity. However, during the drought the plant had to pump all the time as it could not pump sufficient water at any given point.

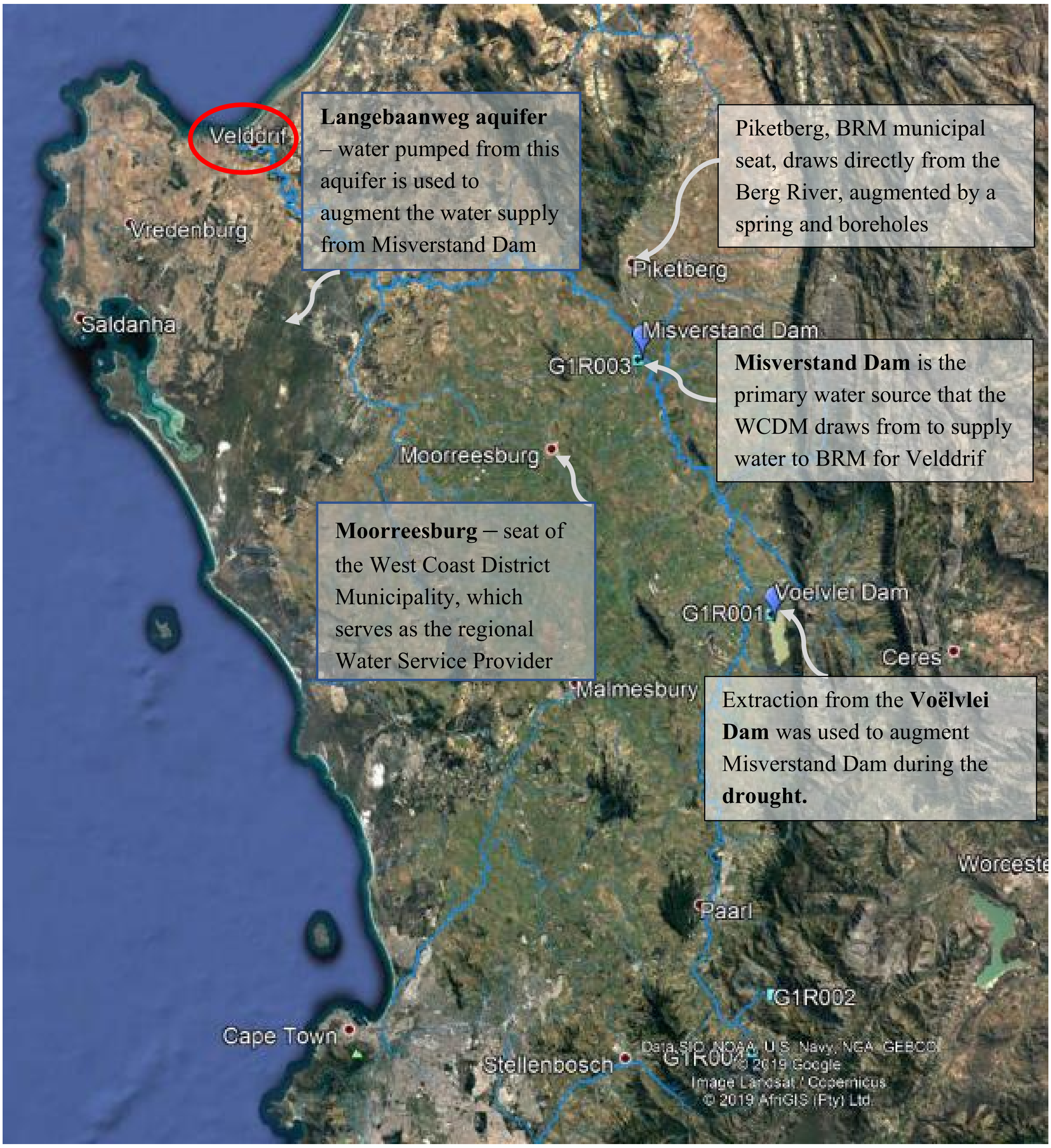


Figure 38 Regional map of the lower Berg River catchment. The map shows the Misverstand Dam – the primary water source for Velddrif, the Langebaanweg aquifer, as well as the Voëlvlei Dam, from which water was transferred to the Misverstand Dam during the height of the 2015-2018 drought.

The next step involved a learning journey to the water infrastructure in Velddrif that was relevant to Noordhoek (Fig. 39). This was done with the CRAs and a Bergrivier municipal official. As the area around Velddrif is relatively flat, there is very little gravity feed of water in the water supply chain with the result that a lot of pumping is required. This illustrated the water-energy link of the nexus, particularly with respect to provision to be made in the event of load shedding. A backup diesel generator is in place in case the electricity supply is off for an extended period. This also applies to the wastewater part of the system, which is highly dependent on electricity to function as it mechanically filters, breaks down solids, aerates, stirs and chlorinates wastewater. The components of the Noordhoek water supply and wastewater system ‘made visible’ to the student and the CRAs through the expert interviews and the learning journey are presented in Fig. 40.

Figure 39 The reservoir plant main electrical 'control panel' (left) and the main pump station at the reservoir (right), highlighting the connection between water and electricity.

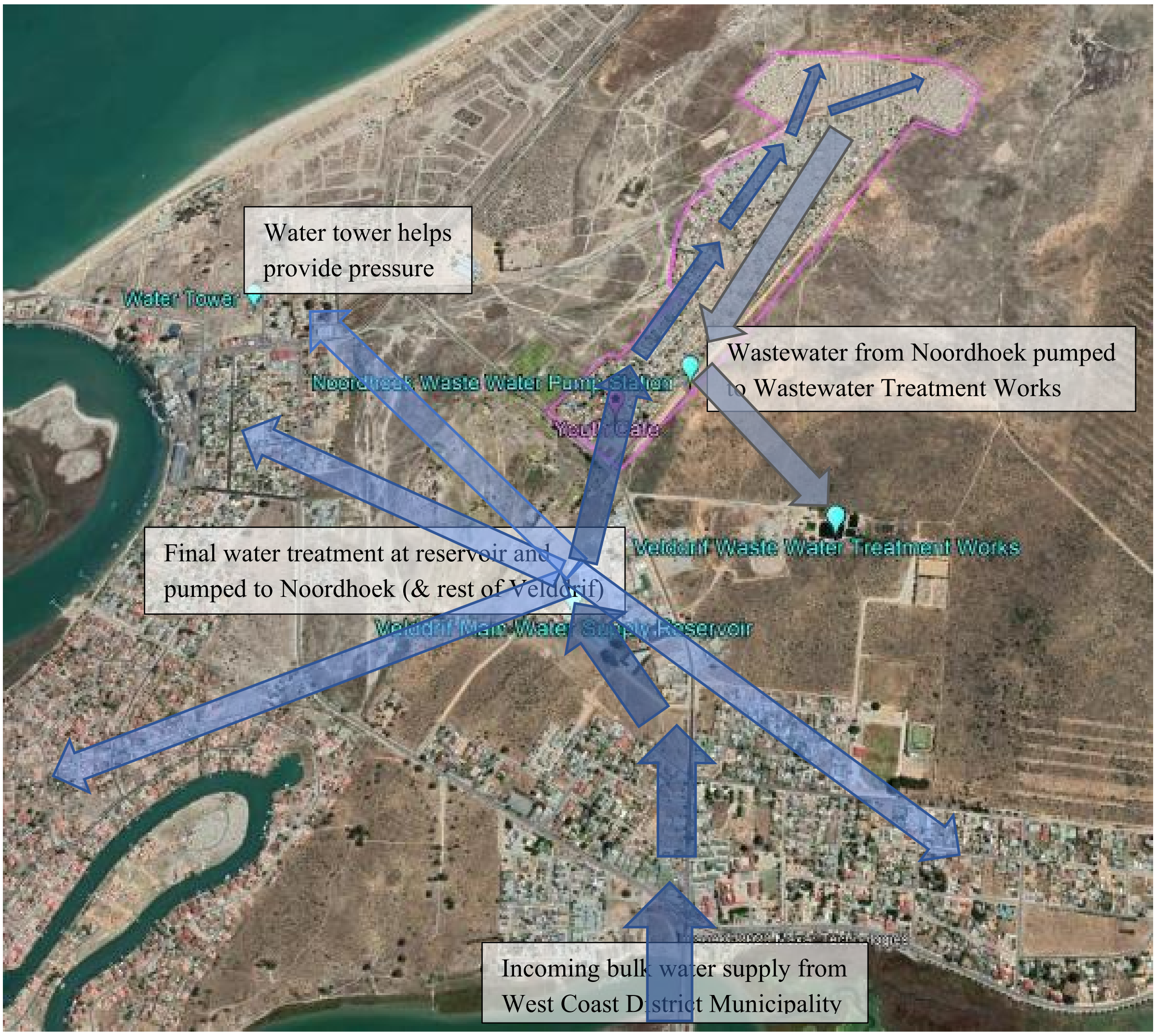


Figure 40 Google Earth map depicting the water supply system to Noordhoek (outlined in pink), generated through resource mapping.

5.1.1.2 Energy supply system

The energy supply system in Velddrif is dominated by electricity. Although liquid petroleum fuel is used for transport, this is not a major focus of this research. The electricity supply forms part of the broader South African centralised electricity supply system managed by the state-owned utility ESKOM. This electricity is predominantly generated by coal-fired power stations located in the north eastern part of the country, where most of the coal mines are located. Recent years have seen a growth in renewable energy facilities, with the West Coast area being a favourable site for both wind and photovoltaic plants. South Africa's only nuclear power plant is also located in this region, between Velddrif and Cape Town. These alternatives do not directly benefit the local area, as their supply is fed into the national grid and distributed.

The learning journey which detailed the electrical system of the town with specific reference to Noordhoek and bulk consumers was led by a municipal official responsible for electrical services. The BRM purchases electricity in bulk from ESKOM, which has a sub-station located on the opposite bank of the Berg River estuary to the town. This is transferred over the river to the town via the main road bridge and is received in the main switching station on the Velddrif side of the bridge (Fig. 41). This is similar to the water meter point located at the main reservoir in Velddrif that keeps track of the amount of bulk water received.

Figure 41 The CRA youth leader and the Manager: Electrical Services, Velddrif, inside the main Berg River switching station.

The electricity from the switching station is then distributed through the town via a distribution network owned and managed by the BRM. There are two electricity supply lines that feed Noordhoek, these are highlighted as 'line 1' and 'line 2' on the map in Fig. 42. The largest user of electricity in Velddrif is the fish processing factory, which is also one of the major employers in the town. The big retailers are also large consumers of electricity, and some are significant employers. This highlights the connection between energy, food and livelihoods.

Figure 42 Electricity supply system of Velddrif, with a specific focus on the research area of Noordhoek, outlined in pink.

5.1.1.3 Food supply system

The location of Velddrif at the mouth of the Berg River, on the semi-arid west coast, makes it geographically less suited to agriculture. As the river is saline at the estuary, there is a lack of naturally occurring fresh water, the soil is sandy, and the area is prone to being windy, hot and dry. Despite these unfavourable conditions, 16% of questionnaire respondents reported growing at least some of their own food, with the majority of these using grey water as the source of water for the garden. A BRM by-law prevents the keeping of stock animals in the area. The household questionnaire also revealed a heavy reliance on supermarkets and shops for food, some fishing, but no evidence of foraging or hunting as a food source.

The food supply system was mapped using a combination of participatory mapping and expert interviews. The CRAs mapped all the retail outlets in Noordhoek by taking GPS points on their smart phones and downloading these into Google Earth maps. These were primarily spaza/corner shops. The team did the same with the large retail outlets in central Velddrif. The fish factory and other key food processing or food supply points were also mapped. These were considered significant as food producers, even if they primarily serviced the 'non-local' market.

The map depicted in Fig. 43 shows all the spaza and corner shops in the research site, which is where 16.8% of respondents reported doing some of their food shopping. However, the bulk of the food purchases (84.6%) are done at the larger retail stores located in Velddrif centre.

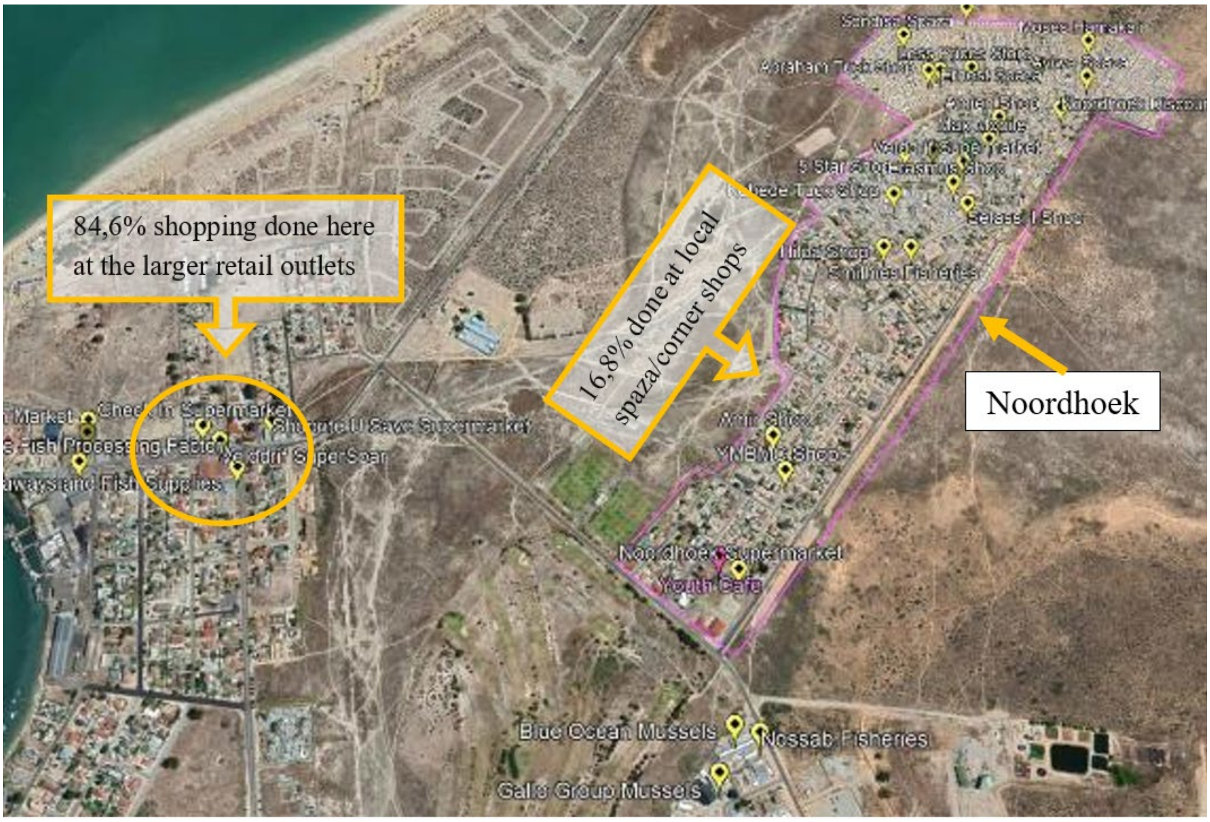


Figure 43 The food system of Velddrif as relevant to the research area of Noordhoek, outlined here in pink.

Interviews were conducted with the managers of the fish factory and the larger retail outlets, all of whom pointed out a vulnerability to electricity load shedding, i.e. energy-food nexus.

5.1.1.4 Summary of nexus linkages or challenges

- Water-energy nexus in the water supply system: Reliance on pumps for extraction from primary water resources (Misverstand Dam and Langebaan aquifer boreholes) as well as Withoogte water purification works and supply to Velddrif reservoir and to residents via BRM reticulation system.
- Water-livelihoods intersection during the drought: Large consumers such as the fish factory were able to install their own desalination plant and did not report any job losses. Yet, this had a negative impact on municipal revenue from water sales.

- Food-water-energy livelihoods nexus: The fish factory, the largest employer, energy user and water user (pre-drought) in Velddrif provides jobs but draws heavily on WEF resources. The fish factory has a standby generator in the event of electricity load shedding, but reported that without a sustainable source of electricity, they would not survive financially.

5.1.2 Hamburg

The resource mapping was the first field work activity in Hamburg, therefore no prior information such as a household questionnaire could be used on which to base the mapping. This resulted in the use of the participatory mapping at a community scale as a means to gather basic information about the WEF resources and to identify potential nexus points. This was done with a group of nine participants, namely the CRAs, community health workers, interns with the Wildlife and Environment Society of South Africa, and the Keiskamma Trust Education Project Manager.

Additional input was provided by community members who the group identified as sources of local knowledge and expertise. The mapping commenced with the drawing of the individual resources at a community scale, then using these to identify the nexus points. Fig. 44 depicts the three WEF resources, circled in blue, red and green, respectively. The map visualises household rainwater harvesting, the use of diesel / oil to pump the water from the borehole to the reservoir and to fuel the tractor to transport locally produced food, a stream and a dam as additional water sources, wood to cook food, and chickens and cows kept as sources of food. This map and other maps were then compiled to create a larger WEF nexus map of Hamburg (Figs 45, 46). The exercise incorporated lessons on scale and how to represent map elements using icons.

Figure 44 Map drawn by Hamburg CRAs depicting the WEF nexus identified with respect to the elements of the water system.

Figure 45 The Hamburg CRAs engaged in debate on a component of the WEF nexus map.

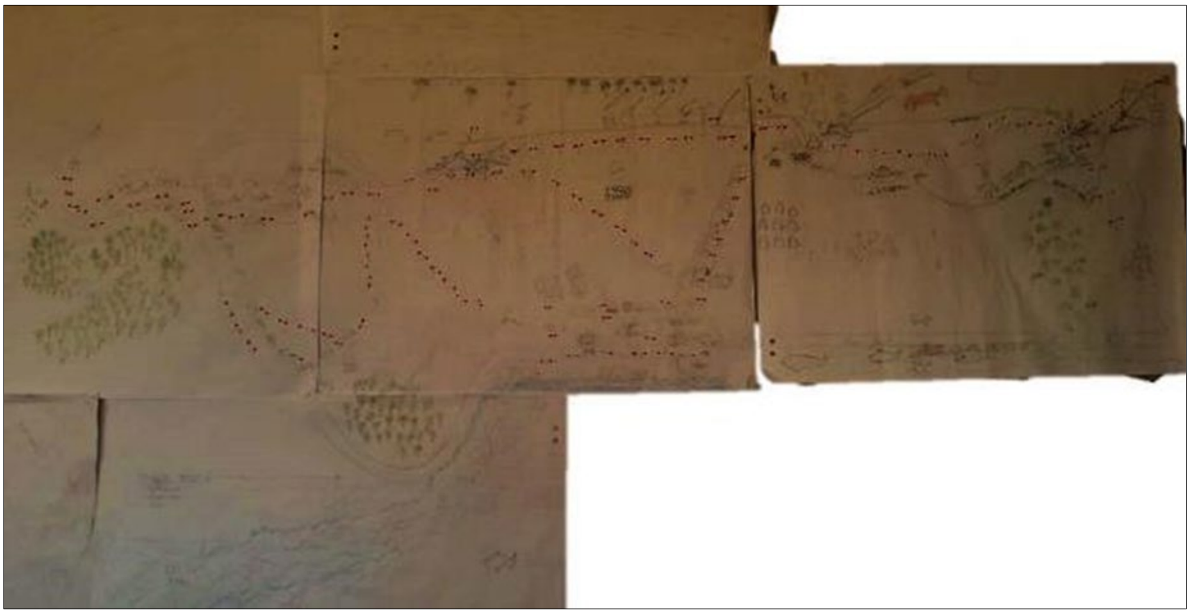


Figure 46 Final WEF nexus map output as drawn by the CRAs of the participatory mapping exercise in Hamburg.

5.1.2.1 Water supply system

The participatory mapping 'made visible' the formal bulk water supply system, but also revealed a large presence of rainwater harvesting and household tanks in times when the bulk water supply is interrupted (Fig. 47). It also highlighted additional water sources such as local streams, a local dam and wind pumps connected to small reservoirs. During extended periods of bulk water supply interruptions, residents report that they trade water with a neighbour that has a tank.

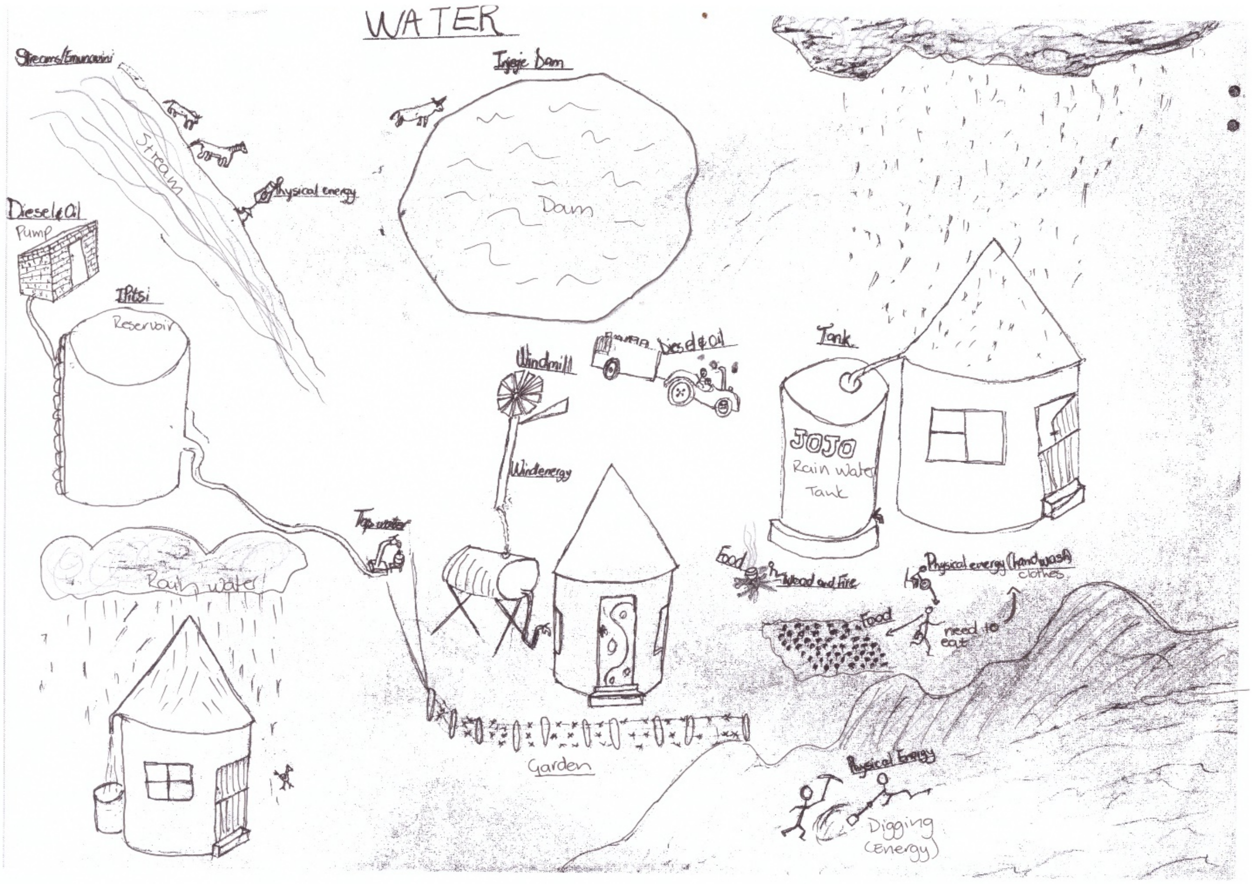


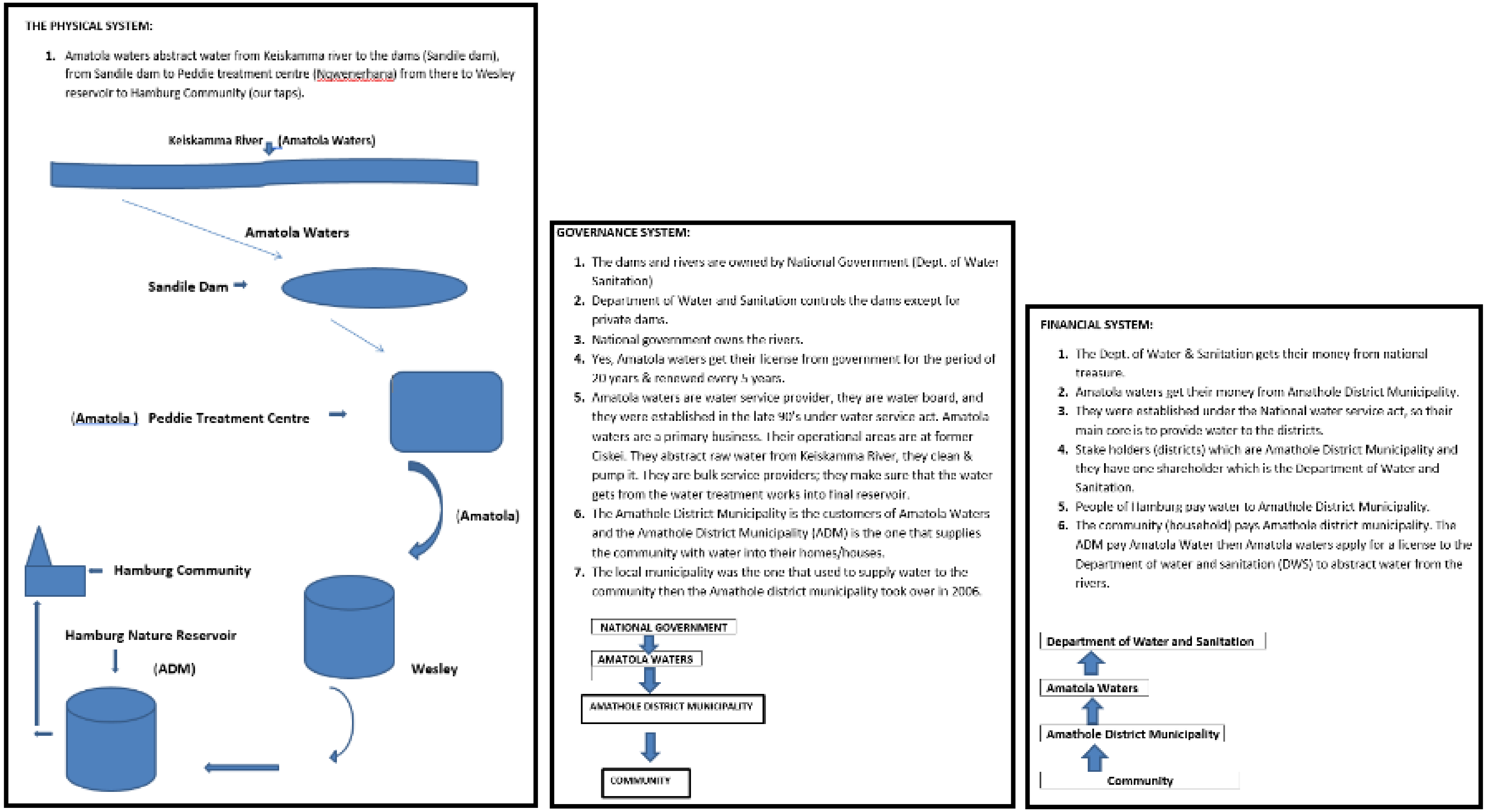
Figure 47 Hamburg water resource map drawn by the CRAs.

The participatory mapping was followed by a learning journey to East London where members of the group met with staff from the Water Service Provider, namely Amatola Water (Fig. 48). A rich discussion followed, enhanced by the fact that the CRAs had already tried to depict, through the participatory mapping exercise, the water supply system for Hamburg. They had some questions prepared, seeking to address the gaps in their knowledge that the mapping had highlighted. The Amatola Water staff member took time to explain the various aspects pertaining to the water supply system as follows.

Figure 48 Hamburg CRAs on a learning journey to Amatola Water, the water service provided for Hamburg.

The water resource is 'owned' by the people and governed on their behalf by the state, i.e. the DWS. This includes the river and dams, except for private dams. The DWS receives a budget allocation from National Treasury to do their work. This includes determining how much water can be sustainably extracted from the national resource, and issuing licences based on this. In the case of dams, DWS works out how much water needs to be kept in the river, i.e. how high a dam wall can be, to ensure that the ecology of the river downstream is maintained. Amatola Water is a water service provided set up by national government in the late 1990's under the Water Services Act. They describe themselves as being a private business with one shareholder, namely DWS. They receive a water extraction licence for a period of 20 years (reviewed every 5 years) to extract raw water from the national water resource, in this case from the Keiskamma River at the Sandile Dam, to purify it at the Peddie Treatment Works, and to deliver it to various Amathole District Municipality (ADM) reservoirs for further distribution. The purification works and the reticulation system are capital assets belonging to Amatola Water and it is their responsibility to maintain these. These costs are covered by selling the water they extract, purify and deliver to the water service authorities – in this case ADM. The amount delivered to these reservoirs is metered and the ADM is billed for this. ADM then uses its reticulation system to deliver this potable water to towns for residents' consumption. Residents are billed by the ADM on the amount they consume as determined by their water meter. The Ngqushwa Local Municipality used to play the role of delivering water between the ADM and the residents, but this was unsatisfactory, and the ADM took over as the Water Service Authority in 2006.

A group assignment given to the CRAs following the visit (Fig. 49) illustrates the level of understanding gained regarding the three dimensions relating to the supply of water to Hamburg, namely the physical, financial and governance systems. This visit exposed the role that governance plays in the water supply chain, identified the different actors, each with their own mandate, but all being reliant on each other to supply water to the community of Hamburg.



THE PHYSICAL SYSTEM:

1. Amatola waters abstract water from Keiskamma river to the dams (Sandile dam), from Sandile dam to Peddie treatment centre (Ngqwenerhana) from there to Wesley reservoir to Hamburg Community (our taps).

GOVERNANCE SYSTEM:

1. The dams and rivers are owned by National Government (Dept. of Water Sanitation)
2. Department of Water and Sanitation controls the dams except for private dams.
3. National government owns the rivers.
4. Yes, Amatola waters get their license from government for the period of 20 years & renewed every 5 years.
5. Amatola waters are water service provider, they are water board, and they were established in the late 90's under water service act. Amatola waters are a primary business. Their operational areas are at former Ciskei. They abstract raw water from Keiskamma River, they clean & pump it. They are bulk service providers; they make sure that the water gets from the water treatment works into final reservoir.
6. The Amathole District Municipality is the customers of Amatola Waters and the Amathole District Municipality (ADM) is the one that supplies the community with water into their homes/houses.
7. The local municipality was the one that used to supply water to the community then the Amathole district municipality took over in 2006.

FINANCIAL SYSTEM:

1. The Dept. of Water & Sanitation gets their money from national treasure.
2. Amatola waters get their money from Amathole District Municipality.
3. They were established under the National water service act, so their main core is to provide water to the districts.
4. Stake holders (districts) which are Amathole District Municipality and they have one shareholder which is the Department of Water and Sanitation.
5. People of Hamburg pay water to Amathole District Municipality.
6. The community (household) pays Amathole district municipality. The ADM pay Amatola Water then Amatola waters apply for a license to the Department of water and sanitation (DWS) to abstract water from the rivers.

Figure 49 Output generated by the CRAs in response to a group assignment given following the learning journey to the local Water Service Provider.

The final stage of the resource mapping involved a learning journey around Hamburg to view the water infrastructure learnt about through the mapping exercise and visit to Amatola Water. The group was accompanied by a retired ADM official and the current ADM official responsible for managing the water infrastructure in Hamburg. The group visited two bulk water supply points to the town of Hamburg (Fig. 50). The experts pointed out that the water allocation for Hamburg does not always reach the village, which is at the end of the supply line. Amatola Water suspect illegal abstractions as being one of the reasons.

Figure 50 Learning journey visit to the incoming water supply line from Amatola Water with two missing covers,

The next stop was to the other bulk water supply source, which was two boreholes managed by ADM which also supply water to the village. The water is pumped from a dilapidated pump house without a roof (Fig. 51) into the reservoirs (Fig. 52). Only one of the two pumps were intact. This water is pumped from the reservoir to the village. This source is also not reliable as the pump shuts down during load-shedding and does not have a back-up mechanism such as a diesel generator. It must be manually reset after load-shedding and is quite a distance from the village. This not only highlighted the WE linkages, but also the relatively poor state of the infrastructure in the area. This town, despite having two separate bulk water supplies, is chronically water insecure, impacting heavily on the wellbeing of the residents.

Figure 51 The Hamburg CRAs on a learning journey to the two boreholes that constitute the second bulk water supply point in Hamburg.

Figure 52 CRAs visit the Hamburg water reservoirs and inspect a cattle 'watering hole' created by a leak in the overflow pipe.

5.1.2.2 Energy supply system

Due to the unavailability of identified experts at the time of the fieldwork, no learning journey to explore the community scale electricity supply system took place. The information presented here is therefore only a reflection from the participatory mapping. The map (Fig. 53) indicates the presence of two transformers, the 'Joko' forest as the main source of wood for cooking and heating, and the taxi that people use when they go to buy gas in nearby towns. The mapping

(Fig. 53) revealed an energy system dominated by electricity use, but supplemented by diverse other energy sources, such as gas, paraffin, manure and candles used for cooking and lighting. Gas, primarily used for cooking, is not sold in Hamburg. Community members buy gas in the nearby towns of Peddie (Ngqushwa) or East London. When private transport is not available, residents transport the 9 kg or 12 kg gas cylinders back using a minibus taxi, which often charges extra. Although transport as a component of the energy system was not a focus of the research, it does highlight an additional cost for the residents in terms of household energy access. Many residents still use wood for cooking, drawing on forested areas surrounding Hamburg. However, many of these are protected areas, leading to tensions between household energy needs and conservation.

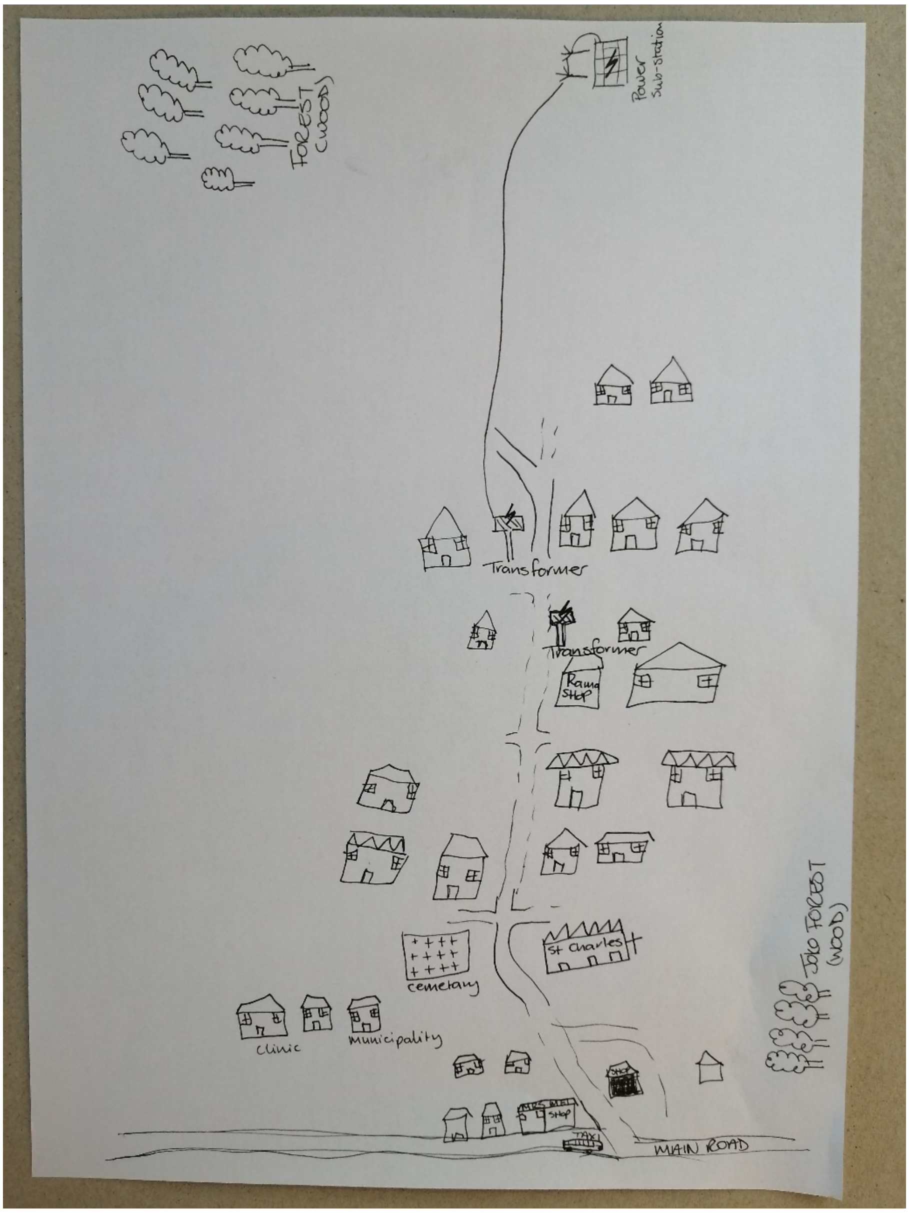


Figure 53 Hamburg energy resource map drawn by the CRAs.

5.1.2.3 Food supply system

The mapping of the food supply system was done through participatory mapping, a photovoice exercise, and a learning journey. Fig. 54 shows the main shops, some of the bigger food gardens and the bread truck. While there is clear evidence of the utilisation of locally produced food, many residents rely on a weekly or monthly visit to retail outlets in nearby towns such as Peddie or East London. A bread truck from East London delivers fresh bread to shops and spaza shops every week.

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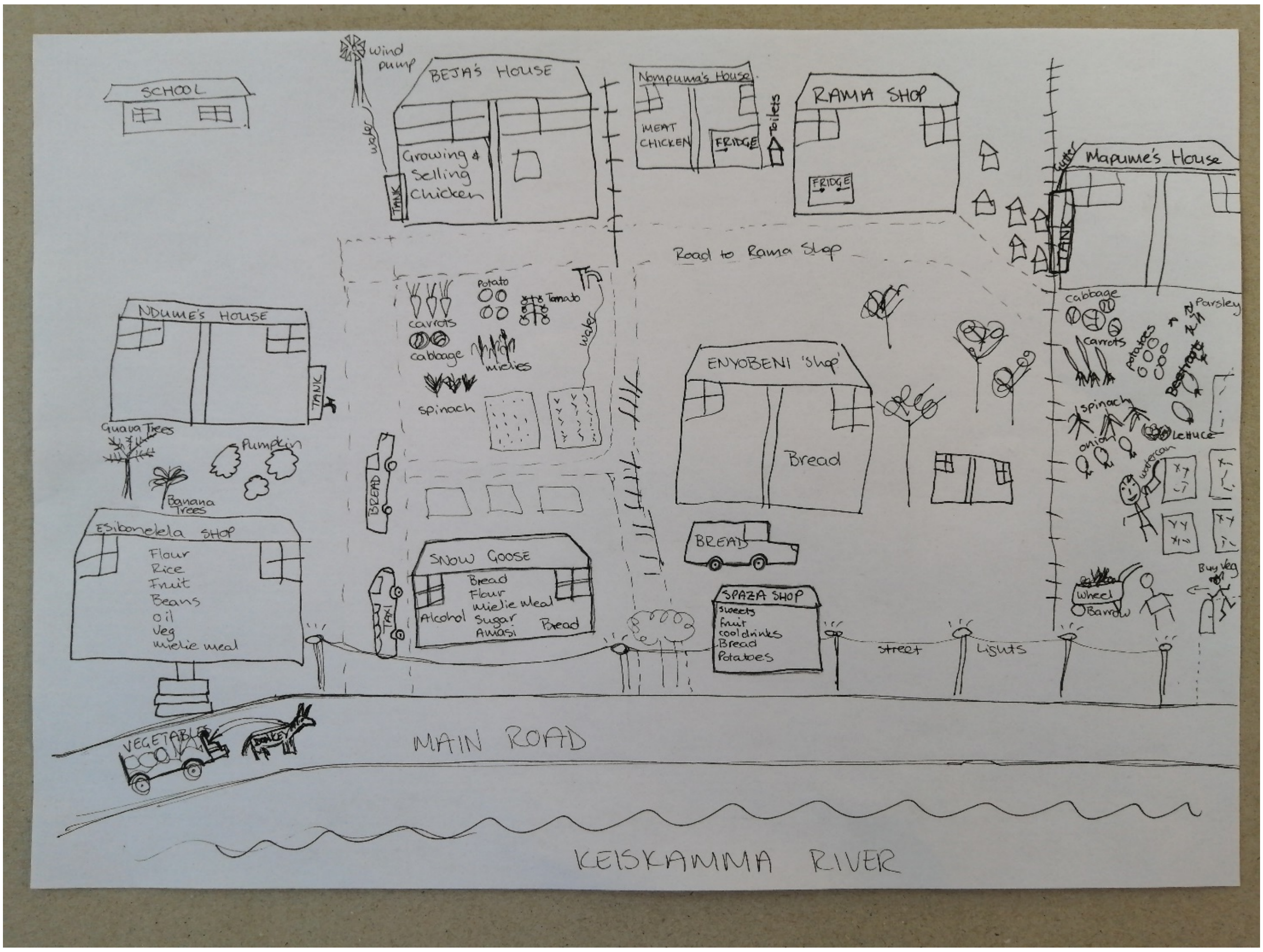

Figure 54 Hamburg food resource map drawn by the CRAs.

'Photovoice' interviews were conducted with some of the key food producers in the community that had been identified during the initial individual WEF resources mapping exercise. The food producers were interviewed about their water and energy needs with respect to their food production (Fig. 55). All local food producers documented to have rainwater tanks, highlighting the vital role water plays in the food system. An example of the energy food nexus was documented at the local chicken producer who requires electric lights to provide heat for the young chicks, as well as wood as an energy source to heat large pots of water that they use in the slaughter process. Another example of a food energy nexus documented was the common use of donkey carts and tractors for transporting produce for sale or barter. This exercise also exposed the linkage between food and livelihoods. The interviewed food producers use the surplus production to either sell or barter.

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We visited this family they have a big fenced garden planted a mealies that is ready for harvest and big melon between the mollies ,they used tractor to plough the garden and hoes to give the mealies a soil .They also used the kraal manure to fertilise the plants. This family don't have a tap yet they used JoJo tank and big plastic containers to save water that are coming from the rain for their garden, to drink, and for their cows. Wood noted outside the house they used it to boil water when they cut the chickens, and to make coal to braai fresh mealies and to cook if there's no electricity.

Figure 55 Output of the CRAs' assignment to record local food producers in Hamburg.

Following this, the CRAs accompanied the researcher on a learning journey around Hamburg, pointing out the key local food production elements and food outlets that had been mapped. Hamburg is characterised by cattle and goats roaming freely. These provide a source of food as well as income. The cattle in this area are highly valued and fetch high prices when sold, as they are healthy due to good grazing and the fact that the state veterinary services come around regularly to vaccinate them. The aquaculture facility, set up and run as an Extended Public Works Programme (EPWP) initiative, was also visited. This provides employment to locals via the EPWP programme but is reliant on electricity to keep the water oxygenated and clean, and to run the pumps. There was no-one present at the facility at the time who could explain the implications of energy outages for the facility. However, the facility did highlight another component of the energy-food nexus. There are several small-scale fishers in the area, who have fishing rights granted through a co-op which has been registered with the Department of Environment, Forestry and Fisheries. They fish both on the beach and on the estuary (Fig. 56) and sell their catches to the limited and mostly seasonal tourists and local residents who own holiday homes in Hamburg.

Figure 56 Small-scale fisher fishing at the estuary in Hamburg.

5.1.2.4 Summary of nexus linkages or challenges

- The water-energy nexus: The energy needs related to the water supply system introduces additional challenges to the already constrained bulk water supply system. The constraints in the electricity supply system (through national load shedding) impact on an already under-maintained and outdated water infrastructure, resulting in local water outages even when water is available in the bulk supply system.
- WEF-livelihoods intersection: Locally produced WEF resources provide and/or augment livelihoods opportunities, such as local food production, wood harvesting, fishing and even trading water in times of constraints in the bulk water supply system.
- Energy-food-livelihoods nexus: There are numerous examples that illustrate the dependence on electricity for food production, e.g. the small-scale battery chicken farming site and the aquaculture facility.
- WEF challenges and livelihoods: In light of the inadequate provision of basic services, residents can simply not afford to rely on these services. They partially try to meet their household needs by utilising resources from the surrounding environment. This includes using wood or dried dung for cooking fuel, having rainwater tanks, stockpiling water in smaller drums, and growing some of their own food. Yet local food production is inhibited by inadequate bulk water supply to the community.

5.1.3 Sobantu and Mpophomeni[14]

The resource mapping in the uMngeni catchment sites was carried out at a broader catchment scale. The first step was the participatory mapping, which was done with both groups of youth together but divided according to their respective communities. These two groups were further broken into smaller groups of three, where each group was tasked with drawing a map of one basic resource as it pertains to their community, i.e. water, energy and food (Fig. 57). These

[14] This section is a contribution of Ntombiyenkosi P. Nxumalo and forms part of her Masters thesis.

were then presented back in a plenary where the WEF nexus was identified through group discussion. This mapping activity was followed up by engagements with experts, some of whom included the CRAs.

Figure 57 uMngeni catchment CRAs drawing maps of the WEF resources in their respective research sites.

5.1.3.1 Water supply system

Due to ease of accessibility and responsiveness of the water sector experts, water was used as the primary entry point to understand the flow of the resources and their influence on one another. The maps drawn by the CRAs from Mpophomeni illustrated tributaries of the uMngeni, the uMthinzima, uMhlanga and Inguga streams, flowing through their settlements and into Midmar Dam. Also depicted was a water tanker supplying Emathangeni, an area in the upper part of the research site. While they do have water infrastructure installed in the houses (i.e. taps), they still experience regular water shortages spanning a week or two at a time. This was attributed to the dam not having sufficient water to pump up the hill where these households are located, as well as the service delivery being affected by leakages. The youth also depicted some rainwater tanks in the community. Fig. 58 shows the water resource map as drawn by the CRAs of the Mpophomeni community (part of the upper uMngeni catchment). It includes the Howick Water Treatment Works (red circle), showing the youth's understanding that the water in the dam needs to be treated before it is supplied to any taps.

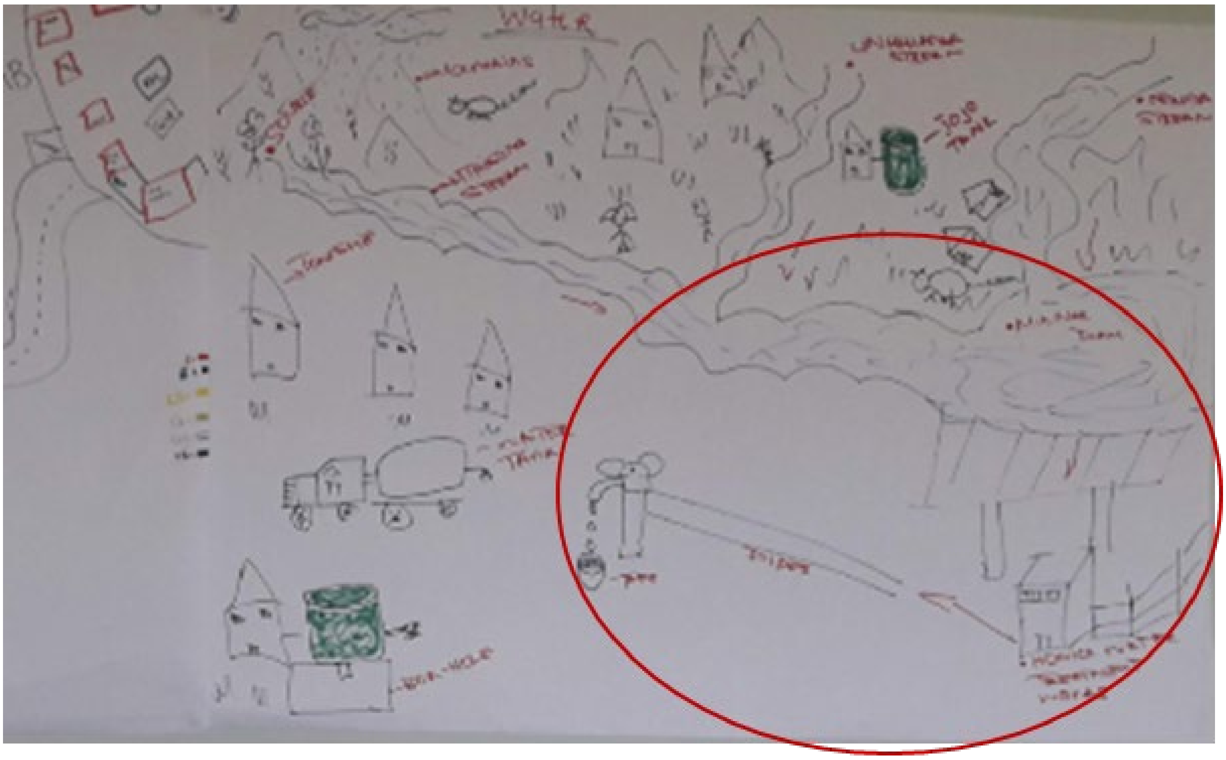

Figure 58 The water resource map drawn by the CRAs from Mpophomeni.

The map drawn by the Sobantu group (Fig. 59) depicted a simpler system in which the water flows from the Msunduzi River into the dam and then into a ‘dirty’ water tank, where it undergoes purification. The way that the group described the water system further indicated that after purification water is pumped into a ‘clean’ water tank from which point it is pumped and finally delivered to the community. The map also depicts the Darvill Wastewater Treatment Works which treats wastewater and sends it back into the system. However, the map does not detail how the wastewater treatment plant connects to the system.

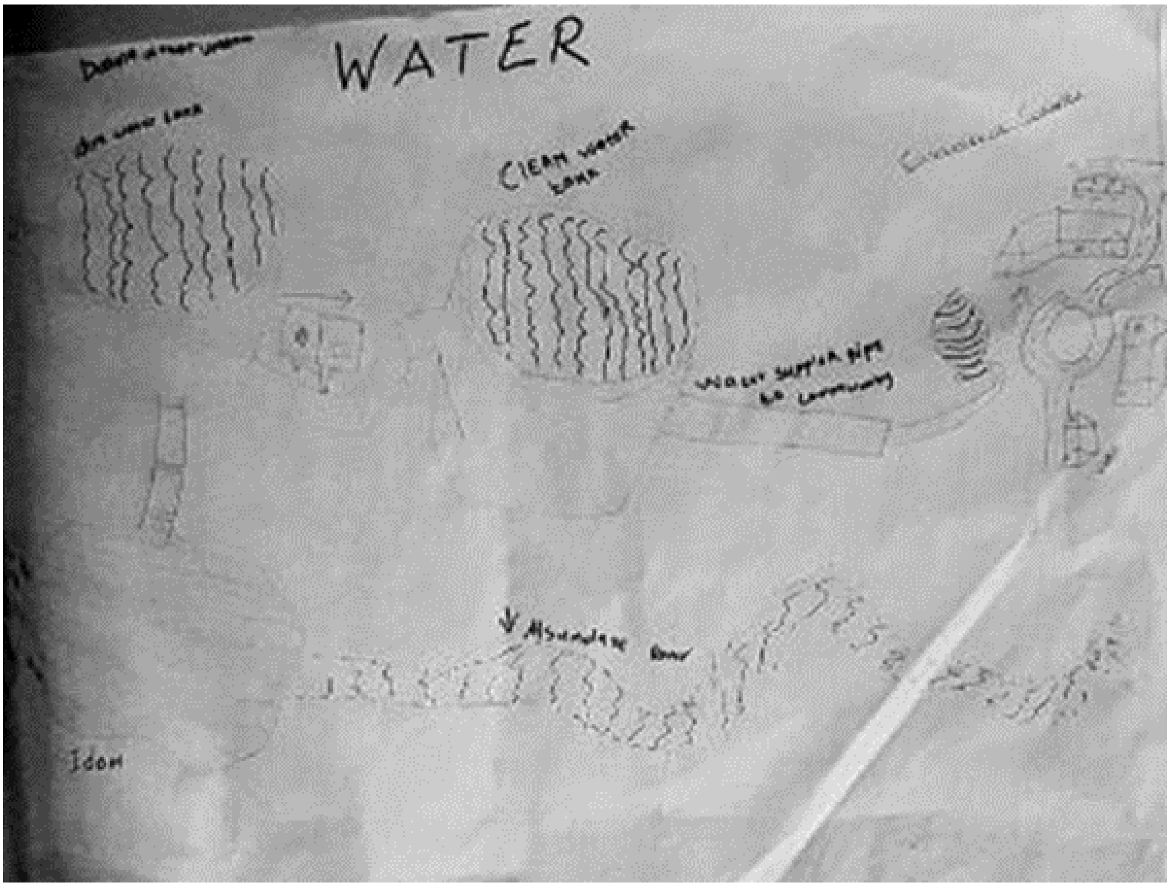

Figure 59 The water resource map drawn by the CRAs from Sobantu. The map depicts their knowledge of the water system that supplies their community. Note on the left-hand side of the map, the water is shown being taken from the Msunduzi River into a dam, then through the Darvill Wastewater Treatment Works, where it emerges into a 'clean' water tank.

The participatory mapping activity and discussion was followed by a talk given by an expert from Umgeni Water (the relevant Water Board) to the student and the

CRAs, explaining the bulk water supply system relating to the uMngeni catchment research sites (Fig. 60). According to the expert, the DWS is the manager and custodian of the national water resource and as such established the Water Boards that are licenced to extract raw water from the water resource in order to provide water services to water service institutions in its service area. Umgeni Water is financially independent, and has only one shareholder, i.e. DWS. It derives its income from extracting raw water from the water resource, treating it to a potable level, then selling the treated water to the Water Service Authority which is the municipality. The municipality then distributes the water to consumers, which include communities, farmers and industries within the municipal area. The payment for the water service is dependent on the consumers, who are expected to pay the municipality, and the municipality then pays the Water Board.

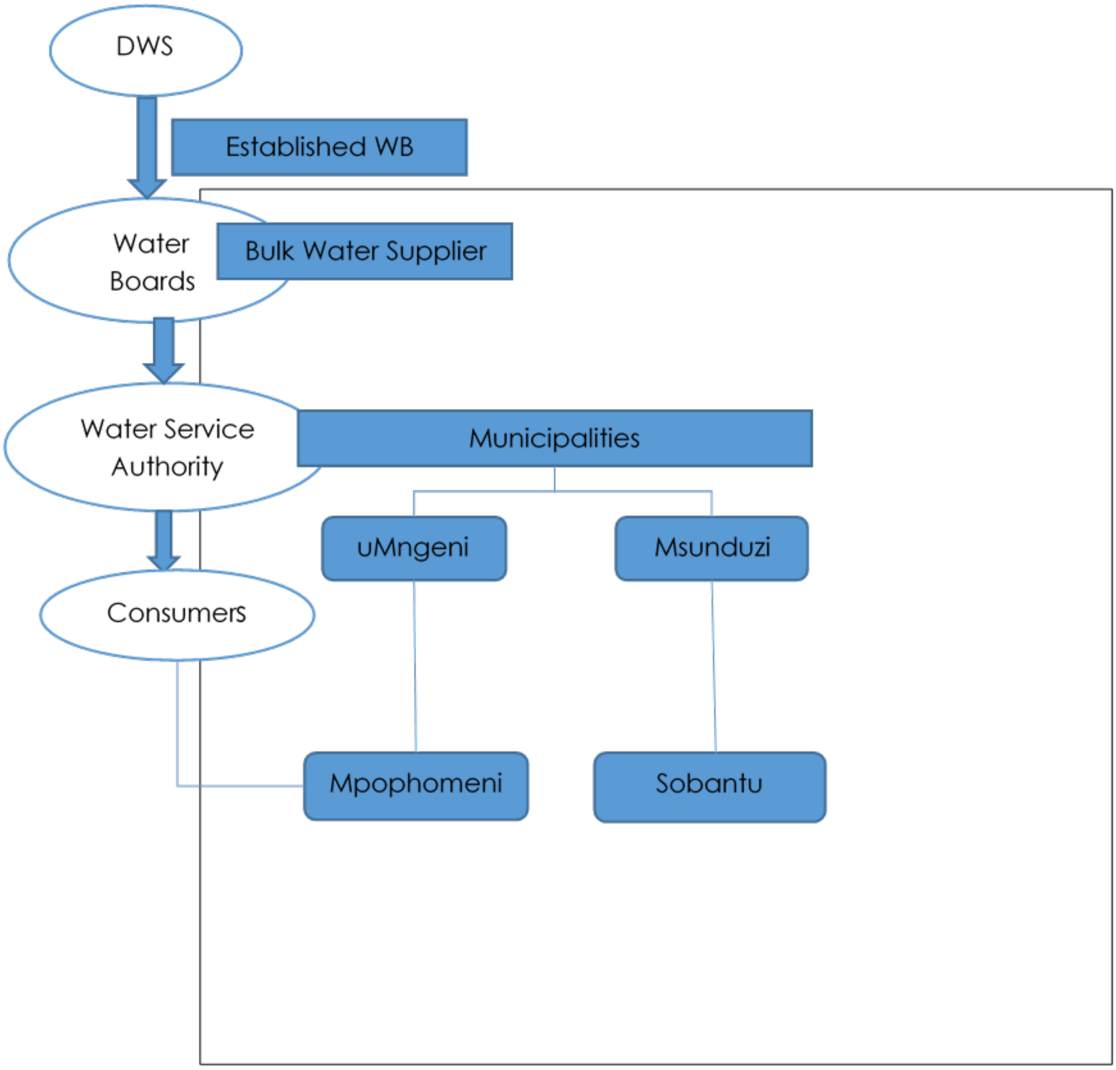

Figure 60 The bulk water supply chain pertaining to the two research sites in the uMngeni catchment as presented by the expert. DWS = National Department of Water and Sanitation.

One further challenge that Umgeni Water reported during this deliberation was the significant revenue losses due to theft of electrical cabling needed to run water treatment and provision infrastructure. This highlighted the water-energy nexus inherent in the provision and supply of water services. This extends to electricity load shedding which not only causes disruptions to water provision and supply, but can also damage infrastructure, for example through water hammers which can damage pumps and cause leakages, which then requires additional maintenance or infrastructure upgrades which have cost implications.

Another issue is the increasing population and urbanisation trends which place additional strain on closed catchments such as uMngeni, exceeding carrying capacity and resulting in degraded water resources. This also results in increased waste production that has implications on other parts of the catchment. For example, Inanda Dam has increasing algae and *E. coli* issues stimulated by increased nutrient loading of most tributaries feeding this dam due to various anthropogenic activities.

Figure 61 Youth from Sobantu and Mpophomeni being shown around the Darville Wastewater Treatment Works.

A learning journey followed to the Darvill Wastewater Treatment Works, where the student accompanied by the CRAs from both sites were shown how the facility works (Fig. 61). This session was designed as a field visit, where another Umgeni Water expert gave a tour around the plant, explaining all the processes that take place from the point the waste water enters the system, the purification process, to when the treated water is discharged back into the system. At the end of the water treatment process, the remaining effluents are discharged using a sprinkler on a piece of vacant land where grass is grown and is then sold off for commercial and domestic use.

5.1.3.2 Energy supply system

Electricity is the main source of energy for the majority of the households at the two research sites. The Mpophomeni energy map drawn by the CRAs (Fig. 62 left) depicts a sub-power station that supplies electricity to transformers in their community. Also depicted is the 'Umngeni Office' (BT) where residents purchase prepaid electricity. The map also shows different forms of energy, including solar radiation which is required for plant growth and cooking when using a solar cooker. Although not applicable to all households in the area, some do have solar water heaters or solar panels. The map also depicts a gas and a petrol station, as well as a local forest used for wood harvesting and a local shop that sells wood as most households use wood to cook food that takes a long time to cook.

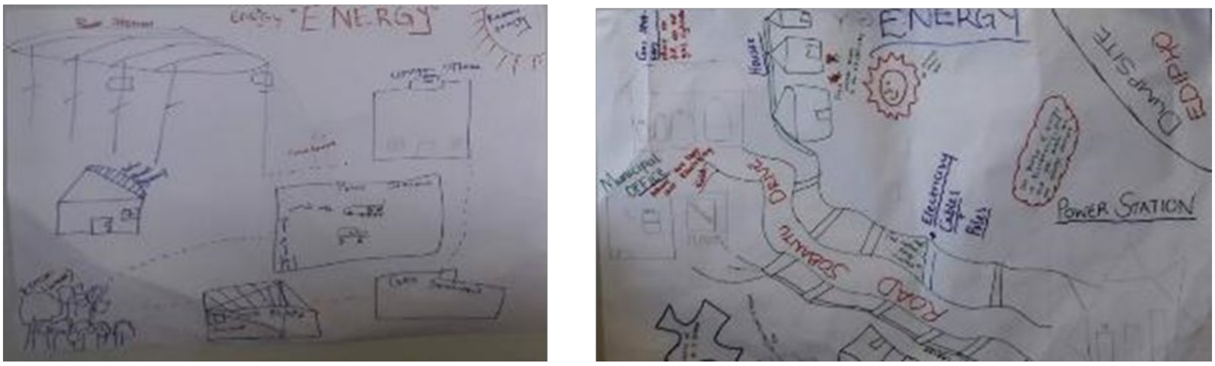

Figure 62 Maps of Mpophomeni (left) and Sobantu (right) depicting the energy system generated by the CRAs.

The participatory energy mapping activity for Sobantu (Fig. 62 right) shows the radiant energy from the sun, and a gas shop which fills empty low-pressure gas canisters used in households for cooking. This shop also sells wood used for cooking, but residents also purchase wood from informal traders that sell wood as a means of livelihood. The Sobantu community buys their electricity from the municipality office and it is the major source of energy. At the top right corner, there is a dumpsite that could potentially be used to produce energy that could be used in the community.

Following the participatory mapping, the energy supply system relating to one of the two research sites was further investigated with an expert from the local municipality. This included site visits to key infrastructure points in the electricity supply system. The national energy utility, ESKOM, generates and distributes electricity to all local municipalities in the uMngeni catchment area via the national electricity supply grid. Two local sub-stations (Fig. 63) receive this electricity and supply the two research sites through their own distribution networks and not the national grid. ESKOM charges the municipalities for the electricity supplied to those points, and this is then supplied using municipal infrastructure. Thus, any losses further down the grid from this point, for example due to theft, must be covered by the municipality.

Figure 63 One of the electricity sub-stations visited in the uMngeni catchment. This is the point at which ESKOM supplies the municipality with electricity and the municipality then distributes it to consumers in the municipal area via its own distribution network.

As illustrated in Fig. 64, the local municipality has different consumer categories according to the use profile, namely domestic, commercial and industrial. In terms of supply, priority is given to industrial customers as, being high consumers, they pay 80% of the electricity bill that the municipality pays to ESKOM, with the remaining 20% being split between commercial and domestic consumers.

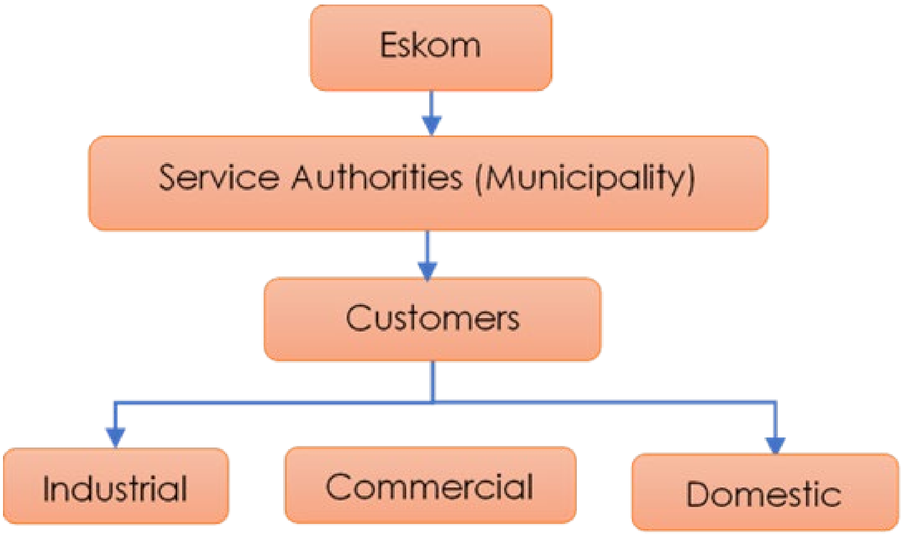

Figure 64 Electricity supply flow showing the three different categories of customer as identified by the local municipality. Each category has different use profiles and therefore tariffs.

The context that this reliance on industry to 'pay the bills' is one in which there is a high degree of poverty in both sites with the majority of households being highly dependent on government grants, resulting in many residents not being able to afford to pay for domestic electricity use. This gives rise to many illegal connections, possibly also because electricity use is not tracked. The illegal connections, as stipulated in the municipal by-law, can result in a R25 000 fine and immediate arrest, which is rarely, if at all, enforced. The municipality does recognise the difficulty residents have in affording the electricity. It therefore encourages the use of energy efficient appliances as well as registering residents as indigent and thus, potentially, qualifying for a lower tariff structure accompanying a household supply restricted to 20 Amps. It needs to be noted that if industrial and commercial customers delay paying their electricity bills beyond three months, the municipality is allowed to cut their connection.

The Msunduzi Municipality supplies Darvill Wastewater Treatment works with electricity. This facility has recently been upgraded which has resulted in increased energy demand. This has benefited the local municipality in terms of revenue generated through electricity sales. However, during electricity load shedding periods, the municipality has to supply the plant with electricity or else the facility will fail, and the wastewater will flow untreated into the Msunduzi River. This can have serious implications on agriculture, as there are farmers that use water from the Duzi River to irrigate their crops. The Sobantu community will also be affected by the toxins from different effluents discharged into the river, as will tourism and significant events such as the Dusi Canoe Marathon, the biggest canoeing event in Africa.

5.1.3.3 Food supply system

Food security is highly dependent on income capacity. Thus, for a household to be food secure it needs to have financial capital to afford staple food. Therefore, unlike water and energy, food is livelihood-based, and requires the availability of water and energy to grow crops, process food and cook food in terms of domestic uses. This makes water and energy central resources needed for food availability which are largely provided as a service through government infrastructure. However, this is not the case with food, which is sourced by individuals either directly from growing, raising, or harvesting, or from retailers and informal traders. The conversation regarding the demand for the supply of water and energy required by the food sector arose during the participatory mapping: energy and water insecurity have implications on many different aspects of daily life. The example given was that the municipality supplies energy to the company Truda Snacks, a food manufacturer located in Pietermaritzburg. This in turn supplies most of its product all over the country. Further, the industry uses potatoes and maize to produce their snacks and instant porridge; both these crops need water for irrigation.

The mapping of the Mpophomeni food system (Fig. 65 left) included the two nearby towns of Howick and Pietermaritzburg, where residents go to purchase their food. Some residents travel further to Pietermaritzburg due to products in retail shops being more affordable than in the closer town of Howick. The maps also gave an indication of the presence of home food gardens. The residents of Sobantu purchase food at retailers in the centre of town, i.e. Pietermaritzburg, and at spaza shops around the community. The map (Fig. 65 right) shows the farmers supplying the factories with food and the factories processing the food to sell to the retailers, who then sell the food to the consumers. This is why the group also identified the industrial area upstream to their community on the map, highlighting that the industries supply food to the supermarkets where it is then accessible to consumers. Additionally, community gardens and home gardens were also marked on the maps, within the community itself.

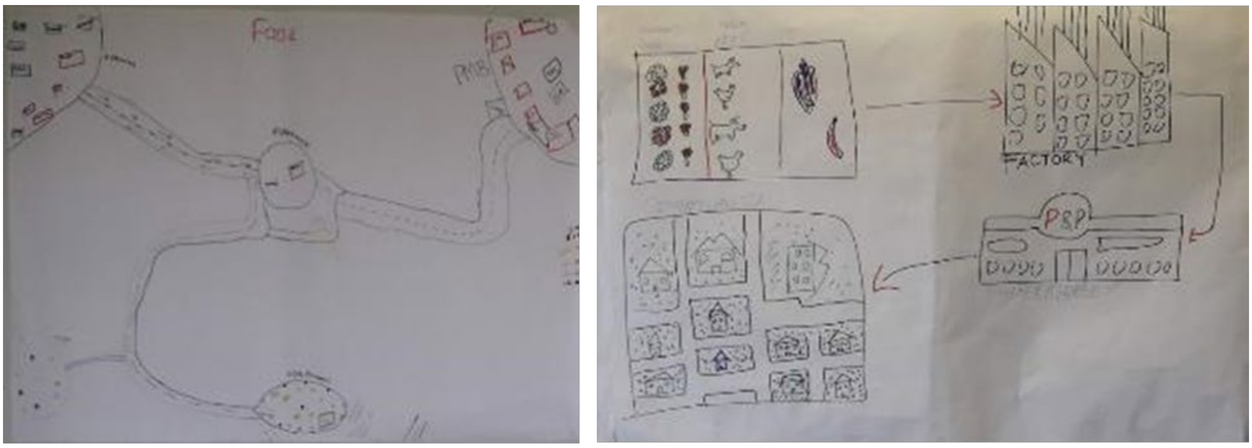

Figure 65 The CRAs' participatory mapping outputs of the i) Sobantu food system and ii) the Mpophomeni food system.

5.1.3.4 Summary of nexus linkages or challenges

- WEF Nexus: The nexus was clearly demonstrated in this activity, e.g. the need for energy to pump water in order to supply this to different consumers. Consumers are the agricultural sector, industries and domestic users that receive the water via the water service authority (municipality). An example discussed was the supplying of water and energy to the Truda Snacks factory, which uses machinery for food processing, the machinery needs water for cooling and maintenance, and energy for processing the food.
- Energy-food-livelihoods connection: The energy department highlighted the threat of illegal connections to the communities as it is not safe. It also increases their costs which may result in limited service delivery, leading to energy insecurities for these communities. Not only does this affect the communities directly, but also the economy as a whole because the main customers for the municipality are the industries. They produce different food items that are important for food security and contributions to the GDP which in return ensures grants to be paid.
- Water-energy nexus: Water and energy are important resources for economic development. The linkages between these resources was highlighted by cases such as load shedding which may cause significant issues for pumping water from the dam to the consumers, and for the Wastewater Treatment Plants which need energy for water purification. Further evidence was gained from the conversation with the representative of the energy department. The upgrade of the wastewater treatment works increased the demand for energy but also benefited the energy department with revenue returns. Thus, not only is the WEF nexus visible as demand and supply for resources, but also when an improvement in one sector leads to an improvement in another sector.
- Water-energy-food-livelihoods connection: Alternative sources of energy were identified but these are only relevant for cooking of food that takes longer, such as sugar beans, or when hosting a ceremonial event. There is high dependency on services provided by the government infrastructure for water and energy. However, the issue of high unemployment prevails. Hence, cable theft and illegal connections of water and energy were raised by the experts. It became clear how severe the issues are for the service authority. Additionally, it was acknowledged that this situation also interferes with the supply chain system and poses threats to these resources, leading to insecurities and further impacts on livelihoods.

5.2 Photovoice as a tool for community engagement and empowerment[15]

Photovoice was used as a tool for community engagement and empowerment. It was, therefore, for the community members to decide which photos were to be included in order to 'tell the story'. Even though the Masters student had other observations, it is critical that the photos chosen by the youth and the stories behind them are well presented as these are the ones that reflect their reality. Overall, both communities reflect on some common issues such as illegal waste dumping (Fig. 66), leaking taps, poor water quality, inadequate infrastructure, the lack of proper sanitation and late responses from the municipality when reporting issues that require maintenance, e.g. overflowing manholes. The following section shows a variety of photos and stories based on the data collected and identified by the youth from the Mpophomeni and Sobantu as critical to demonstrate their 'WEF reality'.

Figure 66 Left: Illegal dumping sites with solid waste. Right: Leaking taps – inadequate infrastructure.

5.2.1 Mpophomeni photovoice results

Figure 67 Left: spilling manhole. Right: uMhlanga stream.

Fig. 67: "We took these photos because we are concerned about water quality and health in our community due to leaking manholes that flow into our streams and further into Midmar Dam. This spilling manhole is a threat to livestock that drinks the water from polluted streams,

[15] This section is a contribution of Ntombiyenkosi P. Nxumalo and forms part of her Masters thesis.

such as the Mthinzima stream. Also, we are unable to use the water from our tributaries to water our crops, because it is contaminated. Hence, our livelihoods are also threatened because we need money to buy vegetables instead of growing our own. Or resort to using tap water to irrigate our crops which puts more pressure on the little money we have; that is why we are unable to pay for water. *E. coli* content has increase in Midmar Dam and this threatens the water sources for the cities of Pietermaritzburg and Durban. Not only does this affect us directly, but also the economy suffers from poor water quality, because water is the main resources that different companies uses." "Our children cannot even play in the water without being exposed to skin rash, nor can we fish anymore because the water is too polluted for aquatic life to even exist".

Figure 68 Left: illegal dumping site. Right: Leaking pipes.

Fig. 68: "These photos highlight other issues we are facing in our community. Illegal waste dumping is a big issue and some of the items (e.g. nappies) the municipality workers that collect the waste, refuse to take. Now, the community members just dump everything illegally. This is an issue because it also affects the hygiene of tuck shops situated close to these areas. Also, the people in our community are not educated about the consequences that these actions have; as long as they are okay within their households, they are ignorant about the rest." "When it rains this waste is washed down into the streams and further into the dam." Further, Fig. 67 (right) showing leaking pipes and taps "which leads to water loss – with serious implications for the people residing upstream because they sometimes do not receive much water as it is lost downstream".

Figure 69 Community garden.

Fig. 69: “Not all is lost; this is a community garden that was started in an area that used to be a dump site. If all illegal dumpsites were to be converted to gardens, this can contribute to reducing hunger in our community while keeping the environment free of dirt, and hopefully rehabilitate our streams so that we can use that water for small businesses such as a carwash in the township”.

Figure 70 Home garden.

Fig. 70: “This is mama Nomusa’s garden; she calls it her beautiful forest. We took this photo because of her encouraging story. She applied for this site from the municipality and it took eight years for the municipality to approve her application. This place had been a dumpsite for a long time and she has turned it into a garden. She is using spring water to irrigate, and practices mulching so that she does not have to use water all the time to irrigate her crops. Also, the radiation energy is the main source for her crops. Additionally, she does a lot of teaching in schools and is also open and willing to teach other women in the community about permaculture gardening.”

5.2.2 Sobantu photovoice results

Figure 71 River pollution upstream.

Fig. 71: "Our community is located downstream of the industrial area, and our rivers are subjected to effluents discharged by these industries. You might have heard about the incident that caused water pollution and killed all our fish in the Duzi River. This is a concern, especially because water is the main basic resource that we need to survive, i.e. to grow food we need water and energy, to cook food we still need water and energy. We cannot even use the water to wash our clothes because of the risks this polluted water has on our health. Back in the day, we used to swim, fish, etc. but we do not have that luxury today because of poor water quality. Also, as individuals we are responsible for the death of our rivers. This needs to change, because if we do not work together to heal our rivers, we might have just lost them forever".

Figure 72 Left: electricity wire connected from outside the house. Right: external device used to recharge electricity pin on the meter box.

Fig. 72: "We took these photos because electricity is the main source of energy in our community, however, most people cannot afford it, and food always takes priority in terms of affordability".

“Even though we cannot afford paying for water, we were least happy with the prepaid electricity we have had after it was changed from a meter reading to prepaid electricity. This was because we could control how much we are using and try and save until the next month’s payment. However, the prepaid electricity was changed again, it was said to be a trial run and we were told that if we do not agree to the changes the municipality will not assist us should we have any issues with the previous prepaid electricity system. This electricity we have currently, was installed for us by a contractor and it is way too expensive. When we buy prepaid electricity for the amount of R100, we only receive R60, what happened to the rest of the money?”

“Not that this is a good thing, but most households have resorted to bridging electricity because we cannot afford electricity, pay for water and buy food with the little money we have”. (Fig. 72 left)

“Also, it is a rather complicated system, for instance to recharge your prepaid electricity, that small monitor needs to be charged first, so how are we supposed to do all of this when we do not have electricity to start with?” (Fig. 72 right)

5.2.3 Discussion

The specific photos selected by the youth show a strong link to the environmental issues caused by anthropogenic activities and mis-communication between the respective service authority and the residents, i.e. the lack of refuse collection by the municipality and the illegal dumping of waste by the residents. The results showed a strong link to livelihoods, where the issues of unaffordability came up in the stories relative to fluctuating tariffs and a lack of understanding why there is a 40% loss in electricity units when bought from the municipality offices. This further raised the issues of corruption and lack of trust. Further, the results show that there are home and community gardens which are important for food security, especially because food takes priority in terms of nexus interdependencies, and that water, energy and food are the resources that sustain their livelihoods and well-being.

In the case of Sobantu, the community’s main issue was the unaffordability of electricity due to the high unemployment rate. On the other hand, the Mpophomeni community seemed to be more concerned about the inadequate infrastructure, poor maintenance of leaking manholes which impacts on water quality, health and is a danger to children that play around these hazards. Further, they raised the illegal dumping as an issue that is causing conflict among the neighbouring households.

The photovoice methodology proved to be a useful tool for community empowerment. The participatory method gave the community members a sense of increased control or influence, for communicating and addressing issues that impact on their livelihoods and their resources security – or rather their experienced insecurities. Also, the tool contributed to capacity building and skills development of the youth, e.g. through deciding what is relevant information, then gathering evidence through photographs, working together in a group to consolidate everything and writing a report. Most communication and training between the researcher and community members was done in their mother tongue, i.e. isiZulu. This created a very trustworthy environment that enabled us to gain insights into the highly sensitive issues of poverty, food insecurities and political motives of illegal connections, which basically represents issues of theft. Therefore, solutions need to be designed in a co-productive manner that engages and is congruent with the communities' realities around the WEF resources.

5.3 Contextualised narratives

5.3.1 Social relations and dwelling structures – Pniel and Lanquedoc[16][17]

The aim of this qualitative investigation was to understand how social relations either impede or enable access to the WEF resources within Pniel and Lanquedoc (see Appendix 4). Access to natural resources such as water, and the subsequent socio-economic benefits derived from it has been the primary driver in shaping both past and present settlements (Nazemi and Madani, 2018). It would, therefore, provide an incomplete picture if co-existing social issues that influence the nature of social relations, and access to water, energy and food, were overlooked. Thus, the focus group discussions covered key challenges such as education, unemployment, housing and violent crime in the communities. The following sections focus on the housing theme and social relational spaces as they, in many ways, relate to the other challenges.

Housing concerns and the WEF nexus

The key concerns were centred around land, housing tenure and ownership, community hierarchy and the perception that the government had failed the residents in these communities on issues concerning service delivery. It became apparent that access to water and energy was strongly perceived to be related to access to land and/or housing. In both communities the maintenance of and access to water and electricity was observed to be mainly through municipal service provision to registered users. Thus, the emphasis on access to land and formal housing in order to receive municipal services. Backyard dwellers, however, are unofficial residents and were seen to be left out of decisions in comparison to the residents in Pniel who were organised and had immediate access to the municipality via social media. One backyarder shares the following:

" Int' ebangel' ukuba sisokole ukuphendula – ukufika kwethu apha, thina bantu bangena zindlu besingakwazi – besingena say apha eLanquedoc. Xa kubizwa imeeting kwela holo, emaholweni, bekusithiwa umntu onelungelo lokuthetha ngumntu onendlu. So that means thina besingena lungelo lokungena ezi meetingini sibuze. So abantu abazaziyo into yokuba kowenziwa isikolo, kothwani ngabantu abanezindlu bebeyazi."

[16] This section is a contribution of Vumande Mjanyelwa and forms part of her Masters thesis.

[17] Please note that this Masters thesis is still in progress. The student had to take a leave of absence for several months due to illness. The student has resumed her studies and is expected to finish towards the end of the academic year in 2020.

(*"The reason we are struggling to answer your question – when we first arrived here, we, those who don't have houses didn't have a say here in Lanquedoc. When a meeting was called at the hall, they would say only those who owned houses had the right to take part. So that means we [backyarders] did not have the right to be part of meetings and ask questions. So, the people who knew about the school being built were those that have houses.")*

Competition for land and WEF resources seemed also exist between residents who had resided in these areas for long periods of time and the recent immigrants. The Pniel residents addressed concerns with an emerging, unofficial settlement nearby that was seen to be a source of some social ills in the community. Residents in this settlement were viewed as needy and often needed support in the form of food donations by the long-term Pniel residents. In Lanquedoc, this competition manifests as pressure on the infrastructure exerted by what one can term 'compound living'. This is a typical setting of a household with multiple backyard dwellings in one yard that may consist of multiple sub-households or an extension of the household from the main house. As a result, focus group participants discussed in depth the issue of exorbitant and unaffordable electricity bills and infrastructure failure due to an overloading of the infrastructure.

Social relational spaces

In Pniel it became clear that nearly all the social interaction was centred around the local church. All the participants participated in church activities such as the local prayer groups, the bazaar, the men's and women's fellowship and church organised sporting activities. The groups made mention of a collection that was taken during each service to support those in need together with a soup kitchen that they regularly hosted. In contrast, both groups in Lanquedoc highlighted that they had no physical meeting space for any social interactions. Space that was available came at a cost that most of the residents were not able to afford. One participant was quoted saying:

"Enye into ebendizayithetha asina holo lo attendela imeeting. Sinalo qha lolucalu-calulo olukhoyo. Limelwe ngama-coloured. So kunzima thina ukuba silifumane. Mhlawumbi kukho into esifuna ukuyenzela kuyo. Mhlawumbi kukho ichoir esifuna uzenza. Asikwazi nopractice kodwa iholo sinalo. So asilisebenzisi. Kufuneka silirentile kodwa lelabahlali."

("Another thing I wanted to say is that we don't have a hall to attend meetings. Well, we do have one but there is racism. Only the coloureds have access. So it's difficult for us to gain access to it. Maybe, there is something we want to do there – maybe we want to start a choir. We can't practice anywhere yet we have a hall. So we just don't use it. We have to rent it yet it belongs to the community.")

A more accessible and popular area to congregate was a tree in one of the streets called 'Emthini' as anyone – both young and old – was able to simply walk to this tree and there were no restrictions on entry.

Physical meeting spaces were seen as important both for information dissemination on plans for the settlement and a space to expand one's social network. The participants discussed instances where food aid and various other charities had come into the community, yet only a few benefited from this due to lack of knowledge of such events. Furthermore, paying for the occupation of communal spaces not only brought tension but also divided both the community and the financial resources to which a specific household may have access. Thus, the lack of access to this space is viewed as an indirect impediment to access to information regarding water, energy and food in this manner.

5.3.2 Non-payment cultures – Sobantu and Mpophomeni[18]

The Masters student project in the uMngeni catchment attempted to explore the manifestation of the WEF nexus within communities of non-payment culture. This was done through the application of the sustainable livelihoods framework and scaling of resource provisioning through the hydrological lens. The study was carried out in two communities of similar socio-economic settings, Sobantu, and Mpophomeni, classified as urban and peri-urban areas, respectively.

As the study hopes to inform policy development, resource management as well as overall community development, vulnerabilities of such communities must be understood in a very localised context and at a high level of detail. Therefore, understanding the characteristics of the WEF nexus within the communities of non-payment culture became significant for this study. Four main methodological approaches need to be outlined for the purpose of this study, one being quantitative and relying heavily on the population census form 2011. This was followed by a qualitative data collection which utilized two main methods, i.e. a guided conversation complemented by photovoice.

The study shows that household income capacity plays a significant role in both study sites in relation to food security and payment for service delivery. The majority of households are government grant holders with a significant percentage of households living under the poverty line. Due to this, many households struggle with the affordability of services and thus, often cannot pay for water and electricity. They then connect illegally into the water supply system and the electrical grid. Another reason for non-payment is that people actively choose not to pay for basic services because they feel these services are supposed to be provided to them for free. Due to wide-spread corruption, the communities also feel that they are purposefully not informed about decisions made and processes impacting on their livelihoods and their access to basic services. The other issue that was linked to corruption was the change to prepaid electricity as a pilot study in these communities. Hence, illegal accessing of water and electricity may partially also be triggered by miscommunication and mistrust. This is further intensified with the experience of not having a meter in one's yard but, yet, getting a bill at the end of the month.

The results from the guided conversations showed that most households are highly dependent on supermarkets for food. Approximately 70% of their households' monthly income is spent

[18] This section is a contribution of Ntombiyenkosi P. Nxumalo and forms part of her Masters thesis.

on food. Thus, there is a strong link between the income (financial capital) and food purchases as well as payments for rates. Thus, it becomes clear that the WEF nexus at a household level is significantly linked to the respective income capacity of each household. The interdependencies between the three resources were also observed, as in the guided conversations food always took priority over water and electricity in terms of spending money on these. As the W and E dimensions of the WEF have been dealt with in the sense of 'they have been accessed and made available', the only dimension left is F. Thus, it could be one of the reasons that food comes first in the decision-making process, because food cannot be ignored.

The photovoice method was used to complement the guided conversations further and to gain a better understanding of the availability of the three resources (WEF) as well as the communities' accessibility and utilisation thereof. Having applied this tool in communities of non-payment culture, it has brought an insight for this study on how these resources are linked to the current environmental issues and livelihoods within these communities. For instance, the themes and common words that emerged from the narratives collected at a household level, such as water quality, corruption, unaffordability, etc. were confirmed by the stories gathered using the photovoice tool. From this tool, the researcher learned that there is a communication gap between residents and service authorities regarding the demand and provision of the WEF resources and that there are a lot of assumptions about how basic resources are supplied and also expectations of what and how their service provision should look like. As a result, the findings show that there is a need for a cross-scale analysis to better understand where the nexus is strongly represented, while identifying the gaps that may exist within these scales of governance.

The study also investigated the implications of the WEF nexus across three scales of governance, i.e. household, community and the broader catchment scale. This was done to gain a better understanding of livelihoods and social deprivation in relation to the use of, interplay, and trade-offs between the three resources. Thus, a fourth method was applied, which involved three focus group meetings, i.e. with an NGO called Ethembeni, the Sobantu war room committee, and a group of key decision-makers in the wider catchment context. The results showed that most people and organisations in the catchment are aware of the WEF nexus and its interlinkages. However, the biggest challenge and greatest gap lies with the understanding of the concept at a local scale and how it plays out in the reality of lives. Further, a clear understanding is lacking on how the nexus could inform planning in order to ensure the provisioning of the three resources in the long term. In conclusion, the application and implementation of the WEF nexus is foreign and unclear to the planners and decision-makers providing the resources.

The challenges that the broader catchment scale organisations have encountered with regards to achieving a better resources supply and overall sustainable development, were linked to several themes that emerged during the focus group discussion:

- Updated data for setting the ecological reserve

    - Making decisions, such as setting the reserve, is highly reliant on the availability of recent and reliable data, because the information that is not up to date may be misleading, compromising decisions made regarding the supply and conservation of the resource.

- Learning and knowledge transformation
    - Developing programmes and strategies that will educate people and get them involved in activities that improve the sustainable use of the three basic resources are needed. Further, these need to encourage each person to play their part. This will help improve awareness, skills development and most importantly it will empower people.

- Political interference and silo mentality
    - There seems to be interference in different sectors and as a result working in silos becomes a default. There is too much politics that hinders collaborative engagements, internally and externally to each sector. Thus, sustainable development continues to suffer due to political interference. Though there is a clear understanding of how important the WEF nexus concept is, there are severe challenges regarding political agendas wherever the service provision is a concern. These interferences hinder what could become an integrated and holistic approach towards service provision. Thus, until politics steps out of the arena, not much can be done to improve sustainable development. Further, there is a need to engage local political figures such as ward councilors in the conversation because they have the influence on the communities and these challenges can be looked at from bottom-up and top-down or *vice versa*.

- Lack of collaborative governance
    - It was highlighted that sometimes an organisation may be focused on one resource only, i.e. being an organisation that is water focused and developing strategies that do not include energy and food, even though there may be a direct or indirect linkage between these resources. The other issue lies with the scales of governance these organisations function at, which are mostly higher up at national level, where bureaucracy is common. This leads to a lack of collaboration and coordination.

- Under-pricing of water
    - Water resources are an important natural capital that serves both the socio-economic space and the environment. However, this resource is undervalued. In the focus group discussion, it was mentioned that water resources should not be for free; rather, educate the public to be responsible for this resource by making them pay even if it is in small amounts. This may improve the revenue that may be used to improve the quality and supply of water resources.

Several conclusions can be drawn from bringing the above observations together. Regarding the implications of the WEF nexus in the communities of non-payment culture, it can be concluded that most people are aware of the linkages between the three resources (WEF) at their household level – and partially beyond. However, food is the most important resource to them because they must buy food to feed their family, unlike water where they can just ignore the bill since they cannot afford to pay for it. However, this becomes an issue for the service authorities who must settle the bills with the entities they are buying water and energy resources from, e.g. ESKOM and Umgeni Water.

Resorting to illegal connections is a common issue and, according to most households, it is their only option to access electricity as the second most relevant resource at the household scale. Thus, a collective approach amongst different stakeholders is essential to address these issues and develop strategies that will assist with resources availability and accessibility. Here the aspect of affordability is crucial for the community members, but solutions also need to acknowledge the needs of the service providers as well as the importance of better communication.

The study showed that if different organisations, individuals and all relevant sectors from all three scales (household, community and broader catchment) were to work together collaboratively, much more could be achieved, i.e. including the community to participate in matters concerning their resources availability can be a start that will promote and improve, co-learning and empower all stakeholders with knowledge about resources supply chain.

Collecting data at the household level provided an understanding of what is known 'on the ground' and helped to identify the gaps in perception at a higher level about the characteristics of the WEF resources use and access.

5.3.3 Local socio-economic development – Velddrif (Noordhoek)[19]

Research into the WEF nexus at the local level as well as the relationship between the nexus and livelihoods is minimal. Understanding these dynamics is not only a useful informant to guiding local-level strategic planning and economic development but is especially relevant given the South African context of high unemployment, climate change (Mpandeli et al., 2018; Cullis et al., 2019) and a debt-ridden centralised power utility. This case study focussed on the low-income settlement of Noordhoek in Velddrif, a small fishing harbour town, located on the estuary of the Berg River, situated on the west coast of South Africa. The aim of the research was to establish the intersection between the WEF nexus and livelihoods at a household and town level in Noordhoek. This was achieved through applying a mixed methods approach that included a household questionnaire which captured quantitative and qualitative data on resident's livelihoods and household WEF security; semi-structured interviews with experts at

[19] This section is a contribution of Penny Price and forms part of her Masters thesis. Note that the Masters thesis related to this study will only be completed in spring of 2021. The student only enrolled in 2020.

the town and municipal scales which gathered data on key employment opportunities, bulk water and energy consumption and supply, and food production and supply; as well as WEF resource mapping which made visible systems of supply of WEF resources to households in Noordhoek, and in the case of food, of consumption.

With regards to household WEF security, preliminary results suggested that access and availability of water and electricity in the households sampled (n=92) was relatively high with 77% of respondents reporting that they received a reliable water service and 81% a reliable electricity service. Levels of affordability, although still quite high, were lower with 68% of respondents reporting that they were able to meet their water needs, and 67% their electricity needs. Trade-offs between water and electricity were minimal as debt on municipal water accounts is linked to purchases of prepaid electricity units, with the result that few households accumulated large water account debt. In addition, respondents who were struggling to afford these basic services reported that they received subsidisation from the municipality once registered as indigent. The presence of a level of water and energy security at the household scale, largely underpinned by municipal service delivery and support for the indigent, revealed little evidence of the WEF nexus at the household scale. Food purchases however presented opportunity for trade-offs across household budgets with the largest proportion of respondents spending up to 50% of their income on food. Despite the town being situated in a largely rural municipality, there were only two respondents who reported working in the agricultural sector, and 16% who reported having a household food garden. Although regarded as a fishing town, limited direct harvesting of fish resources in the estuary and bay. However, in terms of sectoral representation amongst those employed according to the household questionnaire, 41% are employed in the fisheries sector. This dominates the sectoral division, with domestic work and the public sector following with 13.4% each and a further 10.7% in construction, followed by smaller representation across a range of other employment sectors. The main source of income reported by 62% of households was a salary, with 23% reporting it to be some form of social grant or pension. The single biggest employer in the town of Velddrif, the fish factory – a fish canning and processing operation – is also the largest consumer of water and electricity in the town. The recent drought (2015-2018) resulted in the municipality not being able to sustain that level of supply and the factory was forced to invest in a desalination plant, a technology known for being energy intensive. The fish factory – the very industry the town was developed around – therefore provides an iconic example of the intersection of the WEF nexus and livelihoods at the town scale. In conclusion the study highlighted a relatively high level of household WEF security, largely based on municipal service provision, with little evidence of the WEF nexus at the household scale, or the nexus intersection with livelihoods. However, as soon as the spatial scale was extended beyond the household to the town level, the nexus became visible and a connection with livelihoods emerged, as illustrated by the fish factory and other examples explored in the thesis. It is recommended that future studies apply the intersection of the WEF nexus and livelihoods to the context of municipal-level planning and decision-making, particularly with reference to local economic development where trade-offs between job creation and municipal income streams through service provision could play out.

CHAPTER 6: RESULTS – YOUTH DEVELOPMENT AND COMMUNITY EMPOWERMENT

This section speaks directly to the outputs and outcomes of the methods detailed in Section 3.4, and how these have contributed to meeting project aim 3 (trial a process of involving and up-skilling local youth) and project aim 5 (strengthen nexus thinking). A reflective reporting on the process itself is included as this is considered valuable for any researchers wishing to adopt a similar approach in the future.

6.1 Trialling a process of involving and upskilling local youth

The stepwise framework (Fig. 6) developed to guide the process of engaging local unemployed youth into the research project provided overall consistency in the approach across the research sites. Most steps were followed across all research sites, with minor deviations. A level of flexibility was retained within the individual steps, allowing for contextual responsiveness and emergence where required. Factors driving the need for variation included:

- The data requirements of each student according to the focus of their research interest and discipline
- The nature and capacity of, and arrangement with, the partner organisations
- Proximity to the research site and mobility of students
- Locally specific sensitivities

These variations emerged as the project progressed through the stepwise activities. These are reported on in relation to the framework.

The choice of partner organisation (step 1) played a key role in determining the relationship with the youth and the community at the various project sites. Where the partner organisation was well-established and positively received in the research sites, they were able to introduce the researchers widely to the community. Examples that highlight this include the community trust in the lower Keiskamma catchment site and the conservation trust in the uMngeni catchment. Partnerships with well-established organisations such as these provided access to relevant actors through well-developed social networks as well as to physical infrastructure such as meeting rooms and workshop spaces. Although these were the two most well-established partner organisations, others also facilitated access to the community and provided venues that could serve as a base for the youth and for meetings, for example the partner organisation in the lower Berg catchment site who was running a provincial Department of Social Development project focused on training and capacitating unemployed youth. This enabled access to youth in the area and a building to use as a base for training and organising fieldwork. Furthermore, partner organisations that had a thematic focus in line with the project objectives, were able to target youth for recruitment who had already been exposed to some of the concepts used in the project. This was the case with the conservation trust in the uMngeni catchment. In contrast, the partner organisation in the upper Berg catchment sites was a community trust whose primary focus was to manage land restitution in the area. As such, they were not working directly with youth and their engagement with the communities was around a contentious issue, namely, land restitution. In the beginning, the organisation was extremely helpful in introducing the project team to local stakeholders, facilitating engagement with community representatives and assisting with logistics. However, as the organisation was associated with a drawn-out land restitution process in the area, the trust was negatively perceived by some residents with the result that it impacted the research in terms of trust between researchers and community as well as resistance and scepticism on the part of some members of the community. In the upper Keiskamma site, a unique *modus operandi* was required: the arrangement between the ward and traditional leadership in this community was managed solely by the relevant academic institution.

In three of the sites, recruitment of youth (step 2) was done through advertisements that were created by the research team. In two sites the partner organisation displayed these at prominent sites within the target communities, and in one the research team put the advertisements up themselves. The number of applications received in response to these advertisements from across the three sites was disappointing. The low application numbers were in contrast to the plea from the partner organisations for the inclusion of more than one youth per site due to the high numbers of unemployed youth and their need for upskilling and simply 'something to do'. In the uMngeni catchment, two existing teams of youth were put forward for recruitment by the partner organisation, one in each research site. This was motivated for by the following considerations:

- At the one research site, the team was well established and had been doing part time environment-related work for a while. The funding for this team had, however, come to an end and although the partner organisation was seeking funding for the team to continue, this had not yet come to fruition. In engaging the existing team, the project could provide a bridge across the funding hiatus, retaining and building on the knowledge, capacity, and skills the team had developed. Retaining and building on existing capacity was seen as a valuable contribution to the work of the partner organization as well as to the community in terms of the project aim of embedding WEF knowledge within the community.
- The team at the second research site was a new team and the additional training provided by the project was thought to complement their initial upskilling and training.

This approach of working with existing teams of youth conducting thematically similar work in the area was viewed as an opportunity to deepen their learning and strengthening the knowledge within the communities.

There was variation between the three 'train the trainer' workshops (Step 3) driven by a high need for introductory concepts and training prior to the commencement of field work and data collection, whereas subsequent training was focused on introducing additional data collection methods. The first 'train the trainer' workshop introduced team members to each other from across the three catchments, presented foundational training in the WEF concept and related terms to the students youth and community representatives, as well as introducing the project ethics, data collection protocols, and methods. Given the dynamic nature of this gathering which presented numerous opportunities for peer-to-peer learning and exchanges, it is viewed as a good approach to replicate.

The second and third workshops focussed on introducing the students to the training material developed for the research methods associated with the household audit (workshop 2) and the resource mapping (workshop 3). The 'train-the-trainers' workshops not only assisted in capacitating the students with training material and methods thus growing their leadership capacity to train others, it also gave them an opportunity to share experiences enabling support and peer-to-peer learning amongst themselves as a cohort.

The training of the youth (Step 4) was fairly consistent across all sites with the students utilising the training material that had been developed for this purpose. Variation was introduced only where methods differed, such as the community resource mapping not being undertaken in one of the Keiskamma catchment sites and the upper Berg catchment sites, and the household questionnaire not being conducted in the uMngeni catchment.

In the context of the research scope of each Masters student, i.e. the household level WEF nexus and livelihoods research in socio-economically vulnerable communities, the task of training and managing a group of unemployed youth as CRAs was a significant addition to the students' work programme. The fieldwork and youth component were originally designed to span a six-month period and to take place simultaneously across two sites per catchment, in three catchments, supervised by three academic institutions. The expansion of the number of youth per site created additional demands on project resources, on the students, as well as the youth coordinator who was originally intended to play a minor role in the project, mainly to train the youth at three youth workshops and interface with the community in terms of any community empowerment opportunities and project feedback.

Applying a transdisciplinary approach in research demands a broad range of skills as well as adequate time for engagement. The Masters students were all trained in the biophysical sciences but did not have former training in the social sciences. Social science related skills and training may have better equipped the students for the demands placed on them by the nature of the project. The calibre of the students, however, was exceptional and they all managed admirably. This learning clearly highlights a need to start equipping students better for transdisciplinary studies in the undergraduate training phase.

The use of a financial incentive for data collection worked well but was insufficient for in-depth engagement of the youth in the household data collection process (Step 5). Time and additional resources as well as commitments by the partner organisations are critical factors for incentivising the youth and for generating quality data. Two issues arose regarding payments of the youth. The weekly payment meant that the student had to carry large sums of cash on a Friday, which made them vulnerable from a security perspective. Paying youth only when they collected data resulted in long periods of no payment. This became problematic when there were issues that delayed or interrupted data collection, such as a delay in ethical clearance or the need to adjust the methodology. This would leave the youth 'hanging in limbo', which would interrupt the workflow and relationship being developed, as well as result in a loss of some youth who took up other opportunities. This meant that new youth had to be trained to fill the gaps when required, which was not optimal from a team building point of view or from a project resource efficiency point of view.

The resource mapping (Step 5) provided a rich learning opportunity. It exposed the youth to places they do not usually have access to, like the Water Boards and large-scale infrastructure in their area. This was a powerful way to stimulate awareness and engage youth in nexus thinking. While the initial training and the involvement in the household questionnaires provided an insight into the nexus and clues to the interlinkage with livelihoods, extending the spatial scale through the resource mapping to a community and municipal scale made the interactions between water, energy and food and the specific communities more visible to the youth as well as to the students.

Due to delays experienced by the students in completing their fieldwork, the case study results were not completely finalised by the time the feedback sessions took place (Step 7). The project deadlines did not allow any further delays and preliminary findings were presented. Unfortunately, the development of the feedback sessions had limited involvement of the CRAs in most sites. This was due to the long period between the data collection and the community feedback sessions, which resulted in many CRAs no longer being available for the project. The students therefore prepared the findings for the community feedback workshops. These were arranged through the partner organisations, who assisted with logistics such as venue and communication to the communities involved.

The community feedback in the uMngeni catchment site was the most successful in terms of attendance numbers and range of local actors represented, as well as the involvement of the CRAs and the partner organisation in the feedback event. This can be attributed to the well-established partner organisation in the area and its long-term engagement with the youth and the community through a youth eco-initiative. The contact person representing the partner organisation for that site, added significant value to the project through mentoring the student in the management of the large youth team and engagement with the community as well as introducing the student to key actors in the area. The feedback session in Mpophomeni was integrated as an item on the agenda of a similar community event involving the eco-youth initiative. This reduced duplication and therefore the danger of stakeholder fatigue. The feedback session in Sobantu was also relatively well attended. But the attendance range was dominated by those involved in the work of the partner organisation at that site. This can be attributed to the newly established status of the team in the community involved. This points to the important role existing relationships have in facilitating meaningful access and presence in the sites.

The feedback sessions in the upper Berg catchment sites had mixed results. Whereas the one was well attended and those present engaged with the workshop learning exercises and research findings the other session did not draw any interest by community members nor the partner organisation.

The lower Berg site experienced protest action days before the planned feedback session which resulted in the burning down of the hall that was to be used as a venue. As the protest action was around service delivery, the municipality advised that the workshop should not take place until the issues had been resolved.

The workshop experiences in the Keiskamma sites were similar to the Berg sites. In the one site where the ward and traditional leadership managed the partnership, the community had not been notified of the feedback event and the team arrived at an empty and locked venue. In the other Keiskamma site, where the well-established community trust was the partner organisation, the event was relatively well attended.

Overall, the youth learnt much about the WEF resources and nexus in their own communities. In some instances, they learnt about the bulk supply of the WE resources to their communities and what it involves to get these services (or not) to households. Many learnt about mapping and scale, some learnt about 'photovoice', and others learnt how to take GPS points on their phones and download these into Google Earth. In addition, they were exposed to how empirical evidence and scientific knowledge is generated to better understand the interaction between the WEF resources in their communities. They were trained in conducting quite a complex household questionnaire, some were exposed to household WE audit methods and others were trained in guided conversations. Most of these youth are excluded from tertiary study for various reasons, and they seemed to thrive with the intellectual stimulation of being included in the research process. Important to note is the effort that was made by the project team to keep power imbalances in check through the acknowledgement of both local and academic knowledge as being valuable to the research process. Transdisciplinary research provides an excellent vehicle to addressing these imbalances and in some respects 'brings the university to the people', thus making the research experience less exclusive and in doing so, strengthens academic learning through the inclusion and recognition of other knowledges.

6.2 Eliciting more information about local nexus dynamics

Central to the project approach was the acknowledgement of the importance of integrating local knowledge held by the youth into the research project to better understand local WEF nexus research dynamics. This centred on their knowledge of the biophysical, behavioural and governance elements relating to the use and decision-making processes of the three resources in their communities.

Initial local knowledge inputs were received during early engagements with the youth and community representatives at the first 'train the trainers' workshop (step 3). One of the exercises entailed the participants, in groups according to catchment, going through the questionnaire in order to familiarise themselves with the content as well as assess whether there were any questions that may not be clear, relevant or appropriate to their context. This exercise surfaced useful catchment- and site-specific contextual information such as issues pertaining to language and semantics, local sensitivities, as well as generalised WEF resource access, availability, and use patterns. Specific adjustments were made to the site-specific questionnaires as a result.

In the uMngeni catchment, the youth and representative from the partner organisation went through the household questionnaire together with the student, providing input on why they would not feel comfortable asking certain questions, citing discomfort as they felt they were either insensitive, too direct, or would not elicit the desired information, particularly as the student was interested in better understanding the non-payment culture around water and electricity services. This input resulted in the student exploring alternative methods to the household questionnaire and ultimately replacing it with the 'guided conversation' method.

Engagement with the youth from early in the project also provided valuable spatial information. For example, in the lower Berg catchment site, when planning the sampling regime for the household questionnaire, the youth, with the help of a detailed map of the site obtained from the municipality, were able to divide the site into sub-areas according to how old the areas were. As the site had been developed in distinct areas of low income housing being provided over time, they formed locally recognised and named sub-areas that had quite distinct socio-economic and demographic characteristics that the student would not have been aware of without local input.

The resource mapping (step 6) which drew quite extensively on the CRAs' local knowledge, proved fertile ground for knowledge exchange. The participatory mapping involved the researcher drawing on the youth's knowledge of the area to draft research site scaled maps of the WEF resource supply systems which were subsequently combined into WEF nexus maps of the area. The identification of the nexus points was not straightforward, but once the concept was introduced and examples demonstrated, the mapping groups typically identified many cases in their landscapes. At times the participatory mapping drew on additional community and or expert input but was primarily done by the youth. This exercise produced a visual 'first pass' for the researcher showing the systems that supply water, energy and food to the household, or where community members go to acquire these resources. In most cases the youth's local knowledge about WEF resource supply systems was limited, but this was complemented by the site visits to key local water and/or energy supply infrastructure with municipal experts who explained how the systems worked. A further method was introduced in some of the sites which involved the researcher walking or driving around the research site with the youth and taking GPS points of key food outlets and local food producers. This was accompanied by discussion of how and or when these were used, by whom, etc. providing key insights to the food system in the areas where this exercise was done.

CHAPTER 7: GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATIONS

Research into the WEF nexus at the household and community level and into the relationship between the nexus and livelihoods has so far been minimal. Understanding these dynamics is not only a useful informant to guiding local-level strategic planning and economic development; it is especially relevant given the South African context of high unemployment, climate change, struggling water and power utilities and significant food insecurity despite national food self-sufficiency. This project, set out to address the identified knowledge gap, exploring how the WEF nexus plays out in affecting local livelihoods in diverse areas of South Africa, and how this understanding can support more equitable sustainable development outcomes at the local level.

The general aim of this study was to provide foundational and ground-tested evidence that can inform community development and empowerment as well as the WRC Lighthouse theme on WEF Security, and to identify knowledge gaps so as to inform the direction of future WEF nexus research to support equitable sustainable development in South Africa. A global knowledge review concluded that, while the WEF nexus and the sustainable livelihoods framework are fundamentally compatible, both fail to account in meaningful ways for the political economy and power constellations within and across specific decision-making levels. Policy responses and informed decision-making at multiple scales for the development and protection of local livelihoods and WEF security must acknowledge not only the three WEF components (in terms of availability, access, utilisation and affordability) and their inter-connections, and the five livelihoods capitals (physical, financial, human, social, natural), but also the fluid and rapid processes of urbanisation and resulting shifting insecurities, dependencies, livelihood opportunities and interactions with the local environment. A deeper and more relational focused interrogation of the nexus and livelihoods could lead to positive spin-offs and progress towards achieving sustainable development goals at grassroots level and towards identifying equitable, context-specific pathways towards the Green Economy. While many research questions remain, the study has deepened our understanding on several key livelihood and household constellations that drive livelihood-WEF security.

This explorative study adopted an innovative mixture of quantitative and qualitative methodologies, together with a strong focus on youth and community engagement, up-skilling and empowerment around local WEF nexus understanding. Simultaneously, this approach strengthened the research through the incorporation of local knowledge, and contributed to postgraduate student training.

7.1 The WEF nexus and livelihoods at the local scale

The case studies yielded rich insights into how poor households in different institutional and biophysical settings access and utilise WEF resources, and how specific insecurities or nexus dynamics affect their livelihood opportunities and *vice versa*. The **main findings of the case studies** are the following:

1. The WEF nexus approach is a useful approach to understanding WEF dynamics at the local scale (household, community, municipal and sub-catchment scales) with linkages to livelihoods and sustainable development outcomes. But it is not a straightforward approach and requires careful attention to local context.
2. Livelihood-WEF security at local scale changes in fundamental ways along developmental trajectories, from mainly rural settings characterised by household reliance on natural and social capital (see Mabhaudhi et al., 2019), to urban settings where households become disconnected from natural capital and respond to greater livelihood opportunities in the secondary and tertiary employment sectors. This shift leads to the livelihood-nexus interconnection re-locating to a higher level, namely, to the employer and his WEF resource use and security (e.g. the factory, farm, shop or office), and the household WEF security then plays out through level and stability of employment and income.
3. Livelihood-WEF insecurity in more rural to peri-urban settings is still directly evident in households that depend on employment in agriculture/fisheries. Seasonal or casual agricultural/fisheries workers are often young and recent arrivals, frequently living in backyard dwellings. These living conditions are associated with WEF insecurity.
4. By far the most important determinant of livelihood-WEF security at household scale is the affordability of water, energy and food in relation to income and other expenses. This result cuts across all the case study sites and highlights how all poor households must make trade-offs between purchases of water, energy and food. The nuances of these trade-offs are site-specific. Water is an essential purchase, so that trade-offs and substitutions usually relate to energy and/or food amount and diversity.
5. In the South African context, a household income from a pension or social (state) grant provides significant buffering against WEF insecurity and precarious livelihoods, and this was seen in the majority of households in all the case study sites. These forms of reliable income are not subject to instability in local water, energy and food supply systems, but are used to purchase WEF resource needs which are almost always available in all the sites for those who can afford them. It appears that household WEF affordability is decreasing in line with the failure of pensions and grants to rise annually in an inflation-adjusted manner.

When looking at both WEF and the household in the Berg, Keiskamma and uMngeni, we find that greater **vulnerability** is evident in four groups:

1. Young and small households with one or two incomes (often seasonal or casual) and precarious financial situations; these households are even more vulnerable if they are

backyarders paying their main house landlords for monthly rent, water and electricity with little remaining for food.

2. Pensioner-headed small households with one pension and no other income, and increasingly unable to afford WEF.
3. Households of various sizes (some quite large), where the household head is not employed and there are no or few other income contributions from the other household members.
4. 'Water and energy poor' households with rudimentary water and sanitation facilities, widespread use of energy sources other than electricity (even if available), high levels of poverty, and an increasing inability to afford WEF purchases.

Strategies that seem to provide **resilience** include:

1. The household head earning a stable and good income and able to support even a large family, with improving WEF security (seen mainly in Sobantu).
2. Pensioner-headed large households with multiple additional income sources (seen mainly in Pniel, a community with strong social and family cohesion).
3. Households that have access to land and practice farming or food gardening, and have access to natural resources, such as water for crops and wood as an affordable energy choice (seen in the Keiskamma and to a smaller extent in the upper Berg).

Furthermore, the study yielded insights into catchment- and site-specific similarities and differences in **availability** of, **access** to, and **affordability** of WEF resources. Across all the sites, water, energy and food are available to households, although not always reliably and the demand is often not met. Almost all households have an electrical connection and in most of the sites they are mostly energy secure. However, use of additional sources of energy (gas, wood, candles, manure) is relatively low everywhere (and site-specific), and this could affect energy security if the electrical supply is interrupted or electricity is not affordable. Most households have access to a piped connection to a municipal supply of drinking water, either inside the dwelling or outside. Where this is not the case, such as in large parts of the Keiskamma communities, alternative water sources such as rainwater and groundwater are important. Here, water security is a serious issue for many households, and a major factor is the time taken to collect water. Most households are food secure or mildly food insecure, but in some communities, there are households that are moderately to severely food insecure. Almost all households purchase their food at local formal and informal outlets. Home food gardening is more prevalent in some communities compared to others, depending on access to good quality land and water. Foraging and fishing to supplement household food supply is not widespread even in communities with supposed access to these natural resources.

Coming back to our original **conceptual framework of the intersections of WEF with livelihoods at household level** (Fig. 1), we see that many of our early assumptions have been validated. For all three WEF dimensions, availability is generally not a barrier to WEF security, but the study pointed to access (especially in relation to water and energy services, thus the physical capital) and affordability (relating to income and thus the financial capital) as being significant barriers. However, the 'land' aspect of the framework assumed greater challenges with availability, and fewer challenges with access. As part of the natural capital, land (or lack of it for local livelihoods development) plays a critical role in South Africa. While the study found that the assumptions generally held, some communities do not optimally make use of their land (especially for food production). This was generally explained by the lack of access to affordable water. It is important to reiterate that in South Africa, land and water must go hand in hand for local economic and social development. While national water and land reform policies address this, communities on the ground are not yet experiencing the intended benefits.

Our results align well, in many respects, with the WEF nexus framework proposed for South Africa by Mabhaudhi et al. (2018). Key congruencies include the central role of ecosystems, natural resources and land in more traditional rural settings; however, this role is shifting in complex ways with the progression of urbanisation. The 'Innovations' aspect of the Mabhaudhi framework is relevant at all scales. However, we require a critical assessment of the link from 'Innovations' to 'A sustainable environment and human well-being'. We suggest that this can be provided through a rigorous 'Theory of Change', which may have to be scale-specific, i.e. it is likely to differ between households, towns, and larger scales. The 'Drivers/challenges' of the core nexus are also scale-specific and highly contextualised at local level. We believe that our framework (Fig. 1) highlights the important roles of governance and service delivery at grassroots level, and the fine-grained context provided by the inclusion of human and social capital.

The following sections briefly discuss the main findings for each of the three catchments.

Some finer nuances of WEF security at household level emerge from the **Keiskamma catchment** (Hamburg and Melani) findings that household income level and thus affordability of water, energy and food are central drivers. Households that can pay to meet their needs for water, energy and food enjoy WEF security. However, most households do not earn enough, and trade-offs must be made between purchases of water, energy and food. Female-headed households and those with many household members are less energy and food secure in the Keiskamma, suggesting large deficits between income and basic expenses. A reliable source of income (e.g. from agriculture) is linked to greater energy security, and farming and land ownership also lower the probability of high food insecurity in the household.

The in-depth quantitative analysis for the Keiskamma communities revealed a weak positive association between water security and household food insecurity, suggesting that as water security increased, household food insecurity increased. These findings suggest that meeting water demand through increased water purchases in communities where income levels are low may negatively affect household food security through the income substitution effect, since the two (water and food bills) compete for the household income. Attempting to address water security in such communities without addressing income may fail to yield the expected water-food security improvement. The results also indicated a weak positive association between energy poverty and household food insecurity, suggesting that an increase in energy poverty can also compromise household food security. This occurs through compromised food selection choices and changes in cooking habits to accommodate low energy availability. Efforts to improve energy-food security in such low-income communities should therefore focus on providing access to additional energy sources that are not expensive, to avoid the income substitution effect.

The indicator-based analysis for Keiskamma (Table 31) revealed weaknesses in financial, physical and human capital, but strengths in social capital and, to some extent, natural capital in both communities. The latter two capitals appear to constitute important coping strategies in the face of significant financial, service delivery and educational challenges. These require short-term attention (as per SDGs), but in the longer term the area could develop greater livelihood opportunities around its natural capital, given access to sufficient water resources for this purpose.

The qualitative study conducted in the **uMngeni catchment** (Sobantu and Mpophomeni) was confronted by a particular challenge in this region, namely, the culture of non-payment for municipal services received by households. Most of the households are government grant or pension holders with a significant portion of households living under the poverty line and unable to pay for water and electricity. Another reason for non-payment is that people choose not to pay for basic services because they feel these services are supposed to be provided to them for free. Further, due to corruption, the communities feel they are left in the dark about other decisions made that impact on their livelihoods and this has resulted in a breakdown of trust. Understanding the characteristics of the WEF nexus within the context of the non-payment culture became a significant focus of this case study.

In the uMngeni communities, most households are highly dependent on supermarkets for food, with approximately 70% of household monthly income spent on food. Thus, there is a strong link between income, food purchases, and payments of municipal bills (water, sewage, electricity). Interdependencies between the three WEF components were observed regarding spending decisions, where food always took priority over water and electricity. Illegal electricity and water connections were also common. As the water and energy dimensions of the WEF nexus have ‘been dealt with’, in the sense that ‘they have been accessed and made available’, food comes first in the decision-making process, because food is essential. However, the non-payment is an issue for the service authorities who must settle the bills with the utilities they are buying from, namely, ESKOM and Umgeni Water.

The indicator-based analysis for the uMngeni (Table 31) showed weaknesses in financial and natural capital in both communities, and strengths in physical and human capital. There appear to be missed opportunities for livelihood development in agriculture/forestry/fisheries in these communities (especially Mpophomeni), especially considering the relatively good educational levels attained. However, the urban community of Sobantu is weaker in social capital compared to the peri-urban (but with rural characteristics) Mpophomeni. This remains a poorly understood factor in livelihood-WEF dynamics.

The water-energy-food security nexus at household level is not obvious and direct, but rather complex, depending on several socio-economic and location-specific factors. This is borne out by results for the Noordhoek community in the **lower Berg catchment**. Trade-offs between water and electricity purchases were minimal as debt on municipal water accounts is linked to purchases of prepaid electricity units, and few households accumulated large water account debt. This water-energy security was largely underpinned by municipal service delivery and support for the indigent. Food purchases, however, presented opportunity for trade-offs in household budgets. Despite the rural location of the town and its strong connection to the estuary/ocean and fisheries, direct use this natural capital by poor households was limited. Rather, a high proportion of the residents are employed in fish processing, and the case study showed how the intersection of the WEF nexus and livelihoods occurs at the town rather than the household scale.

The indicator-based analysis for Noordhoek (Table 31) revealed weaknesses in natural capital, and to a lesser degree in financial, human and social capital, but strength in physical capital. The latter reflects a relatively strong local service delivery. Development of the human and social capital of this community could strengthen it and support further local job creation in the secondary and tertiary sectors.

Finally, the two communities in the **upper Berg catchment** (Pniel and Lanquedoc) show some similarities. Municipal service delivery is generally good but perceived as expensive. Trade-offs appear to be made at the expense of food diversity, and substitution is seen in the energy component of the nexus. Owing to their location in proximity to centres of strong economic activity and diverse job opportunities (Stellenbosch, Franschhoek) and the surrounding profitable wine and fruit farms, livelihoods are strongly linked to agriculture, but are equally strongly positioned in the secondary and tertiary sectors. However, households in these settlements do not appear to benefit greatly from direct access to natural capital. As for Noordhoek, the intersection of the WEF nexus and livelihoods mostly occurs at the area-wide economic scale rather than the household scale.

The indicator-based analysis (Table 31) identified several contrasts between Pniel and Lanquedoc, which can be related back to their respective histories and current demographic character. Both showed weaknesses in natural capital (as discussed above), but Lanquedoc also revealed weakness in social capital (as discussed in section 5.3.1) as well as human capital (lower educational achievement than Pniel). Pniel showed some weakness in financial capital, relating to the high proportion of households reporting declines in affordability of all three WEF resources. This may relate to the creeping gentrification experienced by this community and the high proportion of pensioners.

Three **multivariate analyses** were conducted across six sites in the three catchments. Overall, we found that households clustered into distinct household types based on sets of household and WEF variables. These clusters generally cut across the different communities in the Berg and uMngeni catchments, so that the geographical location (catchment or position within the catchment) was less important than household demographic and economic factors in explaining their WEF security. However, the household-WEF typologies were very different in the

Keiskamma communities, where unique demographic characteristics, economic deprivation and lack of certain basic services lead to associated WEF challenges in the households.

The clusters were separated primarily by variables describing:

(i) Dwelling structure and type; age and gender (Keiskamma only) of the household head; duration of residence of the household head in that community; income from a pension and/or income from wages/salary/profit; number of household members; and the number of household members contributing to income;
(ii) Access to sources of drinking water; distance to drinking water, toilet type (flush versus other, inside versus outside), whether water demand is met; and the trend in water affordability;
(iii) Electricity as the primary energy source; other energy sources for cooking and lighting (electricity, gas, wood, candles); and the trend in energy affordability;
(iv) The percentage of household income spent on food; trends in food affordability and food diversity; and the growing of own food.

The **first multivariate analysis** included the three Berg communities and Sobantu. The focus was on household and food variables, with one water variable. One half to three-quarters of the Berg community households are young and small (four or fewer members) and are experiencing declining food security. A small group mainly from Sobantu is showing improvement in food security arising from a favourable employment situation of the head. Most of the Sobantu households and one quarter to one half of the Berg households are headed by a pensioner. In these households, size and additional income sources vary, but they are almost all experiencing declining food security.

The **second multivariate analysis** included the three Berg communities and the two Keiskamma communities. The focus was on household, water and energy variables. The Berg and Keiskamma communities separated distinctly into two clusters. The Berg households predominantly receive income from wages/salary/profit and have equal numbers of female- and male-headed households where the head is generally employed and younger than 60 years old. Drinking water is available in the house or yard, flush toilets are mostly used, and water demand is generally met. Energy access has declined in 27% of households, and energy affordability has declined in 61% of households. The Keiskamma households are mainly supported by grants and most household heads are not employed. Households are mostly headed by females (70%), and more than half are older than 60 years. Water is a major challenge: most households access drinking water from a private or communal tap outside the house or a neighbour's tap, flush toilets are rare, and water demand is generally not met. Wood, paraffin and manure are used as additional energy sources. Access to energy has both improved and declined (or remained the same) but energy affordability has mostly declined.

The **third multivariate analysis** included the three communities in the Berg catchment: Pniel, Lanquedoc and Noordhoek. This analysis contained the most variables representing household, water, energy and food dimensions. From the rich set of results, we highlight a few patterns.

There is a clear decreasing trend in what one could term ‘settledness’ or ‘rootedness’ and maturity of a household from Pniel to Lanquedoc to Noordhoek, and this shows certain linkages to WEF security patterns. Pniel is an old community with strong roots, community cohesion, and established infrastructure. This shows in the mostly brick houses with private (indoor) water and sanitation. Although pensioner-headed households make up half the community, younger and smaller households also enjoy these facilities. However, all households are becoming increasingly less WEF secure owing to affordability challenges, especially in Pniel. Energy and food purchase substitutions take the form of using gas rather than electricity for cooking, and growing food, respectively.

Lanquedoc is in transition: one third of households are ‘rooted’, and another one third are growing their ‘roots’. Both types live in brick houses with indoor water and sanitation. The final third of households are young, small (4 or fewer members) and mostly living as ‘backyarders’ in zinc metal sheet dwellings. They typically access water and toilets (communal flush or bucket) outside their dwelling, making water and sanitation their biggest challenge, together with financial constraints. Energy substitution occurs in some households through the use of gas and wood for cooking and other purposes. Two households in Lanquedoc are unique in that they both have no access to electricity and use only wood for cooking and candles for lighting. Lanquedoc thus shows high variability in household-WEF situations. Overall, most households are experiencing declining WEF affordability, possibly linked to rental and service provision costs to landlords.

Noordhoek shows less variability in household-WEF situations than Lanquedoc. It has a younger history of establishment and most households are in the stage of growing their ‘roots’, with younger heads and fewer members. These households live in brick houses with indoor water and sanitation and use electricity almost exclusively as their energy source. However, one third of households are backyard dwellers in zinc metal sheet structures as described for Lanquedoc. Several Noordhoek households have water and sanitation challenges. WEF affordability is declining, as there are more limited job opportunities here compared to the other two settlements.

In summary, three general WEF situations emerge from the intra-Berg multivariate analysis:

1. Private water and sanitation facilities are available, WE demand is met, and WE affordability is stable or improving (very small number in all communities).
2. Private water and sanitation facilities are available, WE demand is met, but WE resources are becoming less affordable.
3. Access to water sources and safe sanitation are unsatisfactory, water demand is either not met or mostly met, energy demand is only partially met, and WE resources are becoming less affordable or remaining the same.

7.2 Up-skilling youth and communities

In this section we reflect on the experiences of the youth development and community empowerment aspects of the project. The incorporation of local youth into the project was well received and supported. However, the planned number of one youth per research site was not seen as sufficient given the high unemployment levels among the youth in these communities. The number of youth per site was increased, with the final number (between five and ten) being determined per site according to the context. Once recruited, the youth were trained in WEF nexus and related concepts, as well as data collection methods, etiquette and ethics. While the youth was introduced to various research instruments the more interactive and participatory activities (e.g. resource mapping and photo voice) turned out be most suited for upskilling the youth. The activities were highly informative and promoted an understanding amongst the youth of the bulk systems of supply upon which their communities rely. They also introduced conversations between local youth and municipal officials who manage these systems.

Incorporating local youth in the project added significant value, particularly in the form of having local representation in the project team, and facilitating access to people and spaces within the research sites that the researchers would not have had on their own. This was particularly useful given that the primary scale of enquiry was the household level, which included sensitive topics at times and thus required a willingness and level of trust on the part of the research participants to collaborate with the research team. This was largely strengthened by involving the local youth. The youth provided guidance to the researchers on local sensitivities and cultural norms, safety tips, and brought local knowledge and language, enhancing the project data collection ability.

The youth and community empowerment component provided opportunities but was not without challenges. Opportunities included exposing the youth to the research process; facilitating a rich exchange between local and academic knowledge systems, which improved understanding and the establishment of a common language between the researchers and local youth; and providing experience for the Masters students in training and managing teams of local CRAs. The approach presented challenges in the form of varying commitment by the youth; varying participation across the partner organisations; and varying quality of the data collected by the youth. Many of these challenges could be avoided by allocating more project time and resources to youth development and community empowerment, and by including the communities at the project proposal stage. This would help to identify research questions and activities that they consider important in the context of the WEF nexus and sustainable local development.

The project's contribution towards upskilling local unemployed youth was maximised in sites where NGOs were already working with the youths with the aim to strengthen their skills and to contribute to community empowerment. Hence the impact of the project was strongly dependent on the supporting structures that are already exists. In many socio-economically vulnerable communities across South Africa such support structures do not exists. In the context of high national youth unemployment this is a major challenge as the youth become disheartened and see no point in engaging with issues surrounding them and that affect their daily lives. Based on this understanding it is suggested that future research projects (funders and research teams) that would like to contribute to upskilling the youth to carefully assess how they can best they can contribute to the long term development of the youth and the sustainability of on-going initiatives.

7.3 WEF-informed decision-making at different scales

To link the communities with the policy-management cycle, and decision-making around the supply and distribution of the resources, experts from the three sectors that provide these basic resources were invited to participate in the resource mapping activity in several case study sites. The mapping activity provided an opportunity to explore and observe the characteristics of the WEF nexus within the local community context, while evaluating the youth's understanding of resource flows. This mapping activity was complemented by the experts' engagement, which gave a clear understanding of the resource flows even at a broader catchment scale, as well as the costs involved in this supply chain. It highlighted how crucial it is to know what is happening on the ground, i.e. within these communities, in order to ensure equitable service provisioning. Having an understanding of the consequences of consumers' misconduct – such as illegal connections and theft – enabled the users, i.e. community members, to see the effects on the finances of the respective service providers, and how it translates further into effects on every stakeholder, directly or indirectly, i.e. threats to resources security due to cable theft and resources degradation due to pollution. Further, understanding a cross-scale linkage is a challenge on its own because higher level organisations frequently operate within silos due to bureaucracy.

For strengthening WEF informed decision-making at different scales it is important to pay greater attention to cross-scale interactions, especially those that relate to the governance of the three resources. Research can play a critical role by systematically integrating the knowledge generated at the macro scale with empirical evidence from the local scale. Important to highlight is that this knowledge needs to be shared with and validated by decision-makers from various scales. Using participatory learning-oriented approaches and tools can be a great starting point for joint sense-making and for strengthening the conversation. Given the existing power imbalances across decision-maker scales but also across stakeholder groups, it is important that this process is carefully facilitated. These types of engagements can help to better understand which drivers currently inhibiting sustainable and equitable access and utilisation of the WEF resources for certain communities and households need to be addressed at a larger scale, and which drivers can be successfully addressed at the local scale through better communication and collective action as well as integrated landscape governance.

Finally, we highlight that some challenges related to WEF insecurities at the household level are clearly the result of governance gaps within each resource system. For example, major challenges still exist in South Africa's water governance system when it comes to the equitable and sustainable provision of water. As we have seen in the case study sites in the Keiskamma catchment, some of the communities are still deprived of equitable access to water due to inadequate infrastructure and its maintenance. Hence, in addition to considering WEF interlinkages and cross-scale interactions in development planning, it is important to simultaneously address challenges that exist within the individual resource system. Based on this understanding, we recommend shifting the focus from optimisation and efficiency in the context of WEF scarcity to a social justice and equity perspective, and drawing attention to the manner in which power and vested interests control and influence resource allocation processes.

7.4 Policy recommendations

The study supports policy development and strengthening in the following areas:

- Develop policy focusing on packages of infrastructure rather than dealing with infrastructure sectorally as this will be more effective in poverty reduction, with the caveat that households with access to the infrastructure may still be poor in other dimensions, e.g. nutrition
- Improve assurance of water and electricity service delivery especially in areas with a high concentration of poor communities through strengthened governance
- Simultaneously, provide support to poor households to make available more affordable additional water sources such as rainwater harvesting.
- Support for clean and affordable alternative or supplemental energy sources, including rapid scaling up of renewable energy (solar) for household use. De-couple municipal revenue streams linked to water and electricity to create enabling conditions for a transition to a green economy and decentralized supply systems especially in rural and peri-urban areas.
- Improved transparency and accountability on decision-making processes relating to the three WEF resources.
- Local economic development planning that aims for a diversity of job opportunities in the primary, secondary and tertiary sectors, even in ‘agricultural’ or ‘fishing’ areas, since they are vulnerable to water and energy supply and pricing issues which can put livelihoods at risk.
- Create an enabling environment for local enterprise development that leads to a wide choice of income generating opportunities that together can contribute to household income diversification and combined income, and thereby WEF security.

7.5 Research recommendations

The research has distilled a few key knowledge gaps regarding the understanding of WEF security at household level. Some of these questions include inter-generational factors that influence family housing situations; income pooling and income buffering through pensions and social grants; and the role of social cohesion. Since livelihoods in the South African context are becoming increasingly disconnected from ‘natural capital’ as populations urbanise (even in semi-rural communities), the livelihoods capitals could be re-evaluated to better reflect the non-natural assets that play out in providing such livelihoods. We have, through data analysis, identified that income and resource substitution occur in poor households that are unable to afford all their water, energy and food needs. However, a large gap exists in understanding decision-making processes in this regard, covering not only income-expenditure realities but importantly also the role of governance (debt collection, reliable service provision, etc.) in the local (municipal) context.

Future research should concentrate on the following:

- Inter-generational factors that influence livelihood-WEF security relationships at household level (e.g. youth and elderly).
- A context-specific SLA, including a re-evaluation of livelihood assets for South African households and communities that are increasingly disconnected from natural assets, where social capital rarely translates into political activism, and where stable incomes can no longer be expected to form a key component of financial capital.
- Longitudinal studies on WEF purchasing decision-making at household level to better understand trade-offs within the local WEF governance context.
- Linking local WEF nexus research to the scholarship on multidimensional poverty and inequality.
- Integrated research on alternative or supplemental affordable sources of water, energy and food for households and how strengthened WEF security could support greater livelihood opportunities.
- Studies that apply the intersection of the WEF nexus and livelihoods to the context of municipal-level planning and decision making, particularly with reference to local economic development where trade-offs between job creation and municipal income streams through service provision could play out.
- Application of methods and approaches from social sciences (e.g. political ecology or critical institutionalism) that can depict how power constellations and vested interests in households, communities, local institutions and between sectors control and influence resource allocation processes.

7.6 Limitations

This project has been quite ambitious, and, in many ways, we have tested new ground such as involving youth in WEF nexus research and exploring methods for operationalising the nexus in meaningful ways at the local scale. Several limitations must be pointed out in order to interpret the findings/empirical evidence created through this project. It is important to note that this project is primarily based on Master student projects. While we took steps to allow for cross-catchment comparison (e.g. through the joint development of the questionnaire), this was not always possible due to the disciplinary requirements for, and research interest of, each student (leading to an alteration of the questionnaire). In an ideal situation we would have preferred to administer the same questionnaire across all sites. However, then we would have lost some of the context-specific insights and perhaps some of the research sites. Future studies could avoid these trade-offs by having students from different disciplines undertake fieldwork in all study sites focusing on particular instruments and questions (e.g. one student administrating the questionnaire with the same guiding research questions across each site, the other conducting focus groups on social relations in all sites, etc.). The students engaged in a very complex research topic that also required of them to set additional time aside to work with the youth from the communities. However, the funding structure only allowed students to commence their work in the second year. It is, therefore, not surprising that field work activities and analyses took longer than anticipated and that some of synthesis work and thesis completion are still in progress.

It is also important to reflect on some of the limitations regarding the methods employed in this study and how the data was generated. We found that the generation of quantitative data on WEF insecurities using household questionnaires was sometimes perceived to be extractive, intrusive and insensitive, and adjustments made to this approach by some students led to a loss of quantitative information. The Census 2011 data was in this respect very helpful in either verifying certain patterns or filling some information gaps. Further, the data represent a 'snapshot' of livelihood-WEF dynamics at ground level and provide only limited evidence for trends over time in constantly evolving and 'fluid' communities. Our approach to developing livelihood-WEF indicators and indices should be viewed as a first attempt at consolidating the quantitative and qualitative information in a manner that could inform planning and monitoring & evaluation. We believe that, while the results are intuitively sensible and interesting, a more rigorous and statistically validated method should be pursued.

The project used an innovative research approach by engaging unemployed youth in parts of the research activities. Given that the emphasis was directed towards upskilling and awareness raising, the biophysical nexus dynamics may have not been rigorously captured, but it has created a rich understanding of how communities perceive and experience the interaction of water energy and food in their households and communities. The involvement of the youth has especially helped to understand the various manifestations of social capital in the communities, as well as specific vulnerabilities linked to geographical location and household type.

One of the biggest limitations was the time and resources available to address the ambitious project objectives. Research at the household level, especially employing a transdisciplinary approach, takes time and there are often unpredicted context-specific challenges. Working with the youth and the organisations that supported them does require a lot of time and adequate resources to develop trust and joint expectations that together can lead to outcomes that benefit the research but also the community, in particular the youth involved. In this project it was primarily the passion and commitment of the youth coordinator that allowed for a successful integration of the youth component into the project. However, to be sustainable and successful, future projects will need to be adequately resourced in order to develop the partnerships needed for transdisciplinary inquiries. Time constraints also made it necessary to speed up some of the project activities, e.g. the community feedback sessions.

Finally, we would like to highlight that this study is not representative of the whole country. More research needs to be done in other urban, peri-urban and setting to better understand key drivers and patterns that affect local WEF securities and livelihoods.

7.7 Conclusions

This study is the first in South Africa to investigate the interconnections between livelihoods and WEF security at household and community level, in underprivileged rural to peri-urban communities across diverse catchments. Several new and policy-relevant insights have been gained. Direct livelihood-WEF interconnections (frequently related to 'natural capital') in households weaken along the continuum from rural to urban settlements, being replaced by indirect influences of the WEF nexus at places of employment and in settings where water and energy service delivery (comprising part of 'physical capital') are adequate. The implication is that WEF-led policy development and planning will require different pathways of change in rural compared to urban communities. The weakest livelihood capital is 'financial capital', across all the sites used in this research. Household income and the affordability of water, energy and food are the primary drivers of WEF security in poor communities. Where income does not cover all WEF needs, households practice substitution using more affordable options, or energy and/or food needs are not met, since water is essential.

Household factors relating to dwelling type, age and gender of the head, household size and the combined household income explain much of the variability in household WEF characteristics. This finding cuts across all the communities studied. Furthermore, indicators of 'human' and 'social capital' influence how the WEF plays out in each community, being partially catchment-wide (e.g. education levels achieved) and partially community-specific (e.g. social cohesion/trust). They explain to some extent the coping strategies employed by the households when WEF needs are difficult to meet.

Greater livelihood-WEF vulnerability is seen in households with only a pension or one to two members earning some income, very large households where the household head has a small income, and in those living as 'backyard' dwellers or other dwellings with rudimentary water and sanitation facilities.

South Africa is a country of stark contrasts characterised by high levels of inequality and various expressions of deep-rooted poverty and marginalisation which are not easy to overcome. It is, therefore, not surprising that different segments of society have a very different experience with regard to accessing and utilising WEF resources as well as influencing decision-making around the allocation and future development of these resources in the context of their household securities and livelihood opportunities.

The nexus concept has proven itself as a useful concept for understanding and guiding integrated resource management and planning at the macro scale by highlighting the consequences of sectoral silos and inadequate acknowledgement of trade-offs and externalities. Yet, we argue, based on the evidence created through this project, that in order to contribute to the achievement of the SDGs the nexus concept needs to be operationalised in the context of inequality and livelihood insecurities in South Africa. This project was a first humble attempt in this direction by bringing the local scale into focus.

To better inform national and local policy making and development planning, more evidence is required at the local scale. Future projects are, therefore, encouraged to interrogate the local scale in greater depth through a focus on topics such as inter- and intra-generational poverty, the further analysis of meaningful indicators for the five livelihood capitals within the WEF nexus context, as well as by systematically integrating the knowledge generated at the macro scale with empirical evidence from the local scale (cross-scale analysis). One of the key questions that should remain at the forefront of future research and policy making is: How can the WEF nexus concept and thinking be deliberately operationalised to improve livelihoods and secure equitable benefits for the most vulnerable and poor. We believe that this question can only be successfully addressed by involving those whose livelihoods are to be improved into the research process (starting at the design phase) and into policy making processes.

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APPENDIX 1: Supplementary material to the knowledge review

The results of the analysis of the four case studies, as summarized in section 2.4.2, are presented here in more detail.

1.1 Spiegelberg et al. (2017): Dampalit Sub-watershed, Laguna Lake, Philippines

1.1.1 Approach

The research explored the connectivity of upland farmers and downstream fishers through interlinkages of water, energy and food within the watershed. Spiegelberg et al. (2017) used an innovative approach to combining central parts of the SLA with network theory. They used a socio-ecological network (SEN) model guided by the five livelihoods capitals for each of the WEF linkages explored. The following linkages were investigated by means of 176 households surveys in the mid- and downstream areas of the watershed:

- Links within the social groups of farmers and of fishers;
- Links between the social groups and the ecological systems which support their livelihood activities (fishing and farming);
- Cross-links between the food products produced by each group; and
- Direct links between fishers and farmers.

1.1.2 How the nexus is interlinked with livelihoods

The survey and analysis showed that the connectivity of upland farmers and downstream fishers through inter-linkages of water, energy and food was rather limited, i.e. no direct social links existed in the nexus context. The two groups were also weakly indirectly linked through the consumption of the other group's food products (fruits, Tilapia fish) made available at the central market. Interest in, availability and affordability of local food products was limited. On the energy side of the nexus, a high proportion of the population used the same source of charcoal for cooking and other energy uses, sourced mostly from outside the watershed. Similarly, a high proportion of households used the same source of groundwater for drinking, other household uses and irrigation, and they also shared the Central Market in Los Banos for food purchases. Neither the water resources nor the food waste was systematically used as energy source in the study area. The study shows that existing nexus problems such as silo thinking, institutional overlap, scale mismatch, and stakeholder conflict remained as serious obstacles to integrated catchment management and hindered research into the nexus.

1.1.3 Strengths and weaknesses in linking nexus and livelihoods approaches

The researchers concluded that a SEN model can be a valuable tool for a bottom-up approach to the nexus since qualitative and quantitative information can be coupled, different scales integrated, and various stakeholders included. The study confirmed the assumption that fishers and farmers formed two distinct livelihood groups with very limited interaction within the context of the nexus. The analysis was able to bring to the fore some opportunities for strengthening the local WEF system: geothermal and renewable energy; improved nutrition; organic and liquid waste conversion into bioenergy and fertilizer; the role of the central market as a possible hub for a more centralized network around the WEF nexus; and the role of the water, energy and waste collection providers as possible unifying stakeholders.

However, some weaknesses identified for the nexus approach remained weaknesses in the combined approach using the SEN. The methodological approach was not able to capture how the institutional processes and governance arrangements determined the access to water, energy and food. Nevertheless, situating the study in a historic perspective and using the SNE model enabled the researchers to predict why the farmers were potentially more vulnerable than the fishers. In addition, the assessment could not be conducted at an individual or household level, partly because data was not available and there was a high level of mistrust towards researchers due to negative previous experiences. The results are therefore broad and at the level of clusters (farmers, fishers).

1.1.4 How livelihoods impact on the WEF nexus

The study found that "the direct influence of the fishers and farmers onto the Dampalit stream by waste water and organic waste seems to be less significant than that of the sellers and the others" (Spiegelberg et al., 2017:8). Most of the fishers (70%) and farmers (58%) used ecologically safer methods of waste water disposal, with fishers (80%) also using organic waste collection services, and about half the farmers composting their organic waste. In contrast, sellers (83%) discharged their waste water into the stream and discarded their organic waste into open pits or into the stream or burned it (71%). These results suggest that different livelihoods have differential impacts on the sustainability of the nexus.

By providing a historic perspective, the researchers were able to describe how specific changes and trends in livelihoods have changed the local nexus dynamics. For example:

- The shift in the agricultural practices and its impact on water soil and ecosystems: "Over the last 100 years, the land use in the midstream areas of the watershed has changed from cultivating rice for local food security to marketable vegetables to agroforestry of export cash crops like coconut, coffee and citrus fruits. All of these activities had repeating impact on the water, soil and ecosystem through increased erosion, pesticide application and overuse of fertilizer", (p.3) and
- The shift from small scale fishing undertaken by residents to growing fish in pens and cages owned by companies and people from outside of the watershed. This shift was accompanied by significant impacts on water quality and led to increased conflict with the local open-water fishermen.

1.1.5. How challenges in the WEF nexus impact livelihoods

The study found that external assessments of the nexus dimensions can have negative repercussions for local livelihoods. Spiegelberg et al. (2017:10) report: "On the side of the farmers exists a history of negative experiences with the local authorities and the scientists …. Research is perceived as a means to document and reveal the farmers' 'misconduct' and was therefore mistrusted for its possible negative effects on their already fragile livelihood security. From the side of the fishers some degree of mistrust towards the outcome of research was also expressed on an individual level aside the questionnaires. They assigned a drop in their income through fish sales to an international research project's publication which showed that Tilapia, Milkfish and Carp caught off Laguna Lake's southern shores are contaminated with heavy metals and the authors claimed to proof that frequent consumption had affected already the health and DNA of locals negatively." Another example is that increased use of shared groundwater resources in a nearby hot springs resort (for local economic diversification) could lead to conflict with the local population who depend on groundwater for their drinking and household needs and some livelihood activities. Variability in the provisioning provided by the socio-ecological system, due to natural disasters or pests and diseases, drives the farming population to seek income (and thus respond to insecurities in the financial livelihood dimension) through off-season work, working in industry, or working for a daily wage in small businesses. These shifts can have feedback effects on the nexus dynamics.

1.2 Foran (2015): Greater Mekong Sub-region

1.2.1. Approach

Foran stated that nexus studies have been dominated by integrated assessments and complex systems methods, which have created an imbalance by failing to incorporate the political economy. Nexus statements have not yet been "accompanied by a rigorous analytical framework that includes the nexus between financial investment, the developmental state, different classes of people, and distributional outcomes on the ground"; furthermore, "the social dimensions of resource linkages remain thinly described and under-theorized" and the nexus is "insufficiently pro-poor". The study employed both complex systems thinking and critical social science methods in an interdisciplinary analysis of the Mekong resource nexus. It then provided a comparison of the two approaches and a critical reflection on current nexus conceptual thinking, followed by a discussion of the concept of 'regime of provisioning' in the nexus context. The analysis was based on four empirical examples: the Delphi process of the Exploring Mekong Region Futures project; and three of the 'critical system nodes' proposed by Smajgl and Ward (2013) (cited in Foran, 2015): energy demand, fish stocks, and land use change and irrigation. To support the argument and stimulate further research and development of inclusive practice, three linked propositions were developed. Although this study did not formally include a livelihoods analysis, 'livelihoods and migration' was one of the sectors assessed in the Mekong study (Bouapao, 2013, cited in Smajgl et al., 2016), and development impacts on livelihoods took a central role in the analysis.

1.2.2. How the nexus is interlinked with livelihoods

The Mekong study showed that the construction of 12 hydropower dams on the mainstream Mekong River would likely lead to loss of access to wild fish and negative impacts on agricultural production in the delta, thus impacting negatively on fishing and farming livelihoods in Cambodia and Vietnam. In the upper river basin, in Thailand and Lao PDR, dam construction was expected to have both positive and negative impacts on farming livelihoods. The projected negative hydrological impacts of the large dams were not balanced by any of the positive outcomes of the other development strategies, including those which could increase employment opportunities in mining and rubber production, or those which could reduce food prices, such as dry season irrigation and aquaculture. Migration and labour shifts were previously identified as critical system nodes within the Mekong WEF nexus – both speak to the issue of available livelihood options in both rural and urban contexts, and the instability of rural livelihoods and communities. Foran concluded that "socio-political regimes constrain societal investment in three 'nodes' of the nexus previously identified as critical to manage sustainably: energy efficiency, wild-capture fisheries, and diversified smallholder agriculture."

1.2.3. Strengths and weaknesses in linking nexus and livelihoods approach

This paper did not formally link the two approaches, at least not using the SLA framework. However, the argument was made that the combined use of complex systems thinking and critical social science methods can be useful. Foran (2015:665) stated that from the perspective of the 'regime of provisioning', "the nexus can be visualized as the superimposition of regimes: for example, the aggregation of sector-specific regulatory and planning practices in water, energy, and food regimes (cf. Fig. 2) that impose net costs on poor people, along with possible dispossessing impacts." A more nuanced understanding of the nexus can be achieved within a new research agenda: "The argument touches on powerful interests, the emergence of the resource nexus as a new agenda, the likelihood that small farmers and other marginalized actors will be initially disempowered by such agendas, and finally the contribution a regime of provisioning perspective could make to empowering small farmers, rural workers, and those who advocate on their behalf." (Foran, 2015:668) On the other hand, "Because the two approaches differ in focus, theoretical processes, typical sequence of analysis, and techniques, combining them is analytically intensive …, and presents challenges of epistemology." (Foran, 2015:657) Nevertheless, the analysis showed that "each approach has limitations that could be potentially bridged by the other, and thus an interdisciplinary analysis based on synergies between the two approaches is worth pursuing". Amongst other, the critical social science approach has strength in adding a focus on the historical determinants of vulnerability, insecurity or poverty in specific places, and thus support a better understanding of local livelihood dynamics.

1.3. Keskinen et al. (2015): Tonle Sap Lake, Cambodia, Mekong River Basin

1.3.1. Approach

The study was conducted in the Tonle Sap Lake area which is closely connected to the Mekong River and the annual floods which drive the Tonle Sap flood pulse. The pulse underpins the significant food production capacity of the Lake and surrounding area. The study focused on the local scale, but within the transboundary context of the Mekong River system and upstream hydropower development plans. A WEF nexus framework was developed showing the key linkages between nexus themes, with impacts on water (through the hydrological system) connecting energy and food security across the local (Tonle Sap), national (Cambodia) and regional (Mekong) geographical scales. Energy (hydropower) and climate change were treated as external transboundary drivers, while changes in water resources and food security at local scale were investigated together with recent trends in demography and local livelihoods. Thus, two research components focused on 1) hydrology and water resources, using detailed cumulative assessments of the impacts of hydropower development and climate change on the Tonle Sap; and 2) livelihoods and food security, using a trend analysis of key demographic and socio-economic indicators provided by the population census for 1998 and 2008. Finally, the different scales of analysis and the nexus analysis were connected to the livelihoods analysis using four alternative futures (scenarios) for the Tonle Sap. The research was conducted in collaboration with local government authorities to ensure policy relevance.

1.3.2. How the nexus is interlinked with livelihoods

The study showed that water, energy and food security were very closely linked in the Tonle Sap Lake area, and there were strong connections to local livelihoods, especially in agriculture and fisheries. The nexus-livelihoods linkages differed significantly across the three spatial zones of the floodplain and adjacent urban areas, owing to differences in population size and density, and people's relationships to the lake and its flood pulse and their dependence on natural resources. The demographic and livelihoods trends analysis highlighted different states of livelihood structures and livelihood diversification over time in the three spatial zones. Fishing was the most important livelihood activity in areas close to the lake, whereas livelihood structures were more diverse in urban areas. Generally, although absolute numbers of people engaging in agriculture and fishing were increasing, an increasing proportion of people were shifting from resource-based livelihoods to other sources of livelihood. Trends in urbanisation and a shift away from agriculture and fisheries change the relationship to the nexus.

1.3.3. Strengths and weaknesses in linking nexus and livelihoods approach

The study was innovative in demonstrating the importance of differing spatial and temporal scales when studying the nexus in the context of livelihoods. This was achieved by using several research methods simultaneously. The linked approach appears to have merit in situations such as the Tonle Sap where there is a high dependence of livelihoods on natural resources. The use of scenario formulation to provide a connection between geographic scales, nexus dimensions and livelihoods under different water-energy-development and livelihood-development pathways was also a strength of this study. The nexus approach encouraged the inclusion of diverse cross-sectoral stakeholder inputs from the start of the project and facilitated collaborative discussions around uncertainty and the impact of policy choices.

Not all nexus-relevant themes were included in the analysis in the interests of maintaining the focus for this case; this can be a strength but also potentially a weakness if the importance of certain linkages now or in the future are underestimated. For the livelihoods analysis, heavy reliance on quantitative data from the population census meant that spatial coverage was excellent and the main economic activity per household was captured. However, the seasonal variation in the system relating to the flood pulse was missing, and the diversity of livelihood sources, often as secondary and tertiary activities (especially for fishing and related activities) was poorly captured.

1.3.4. How livelihoods impact on the WEF nexus

The analysis found that, while the proportion of people dependent on agriculture and fishing for their main livelihood decreased from 1998 to 2008, the absolute number of people in the agricultural sector increased by 130 000 and the number of people in the fisheries sector increased by 10 700. Thus, over 140 000 entrants into these resource-based sectors placed additional pressure on the existing resource base. On the other hand, increased and more diverse food production could contribute locally and nationally to improved food security. Strong integrated government policies could help to leverage the demographic trends towards livelihood diversification and food security while ensuring the protection of the system for productive purposes and regional energy security.

1.3.5. How challenges in the WEF nexus impacts livelihoods

In this area livelihoods are very tightly connected to the Tonle Sap lake and surrounding area through agricultural activities and fishing, and two-thirds of the working population had these activities as their primary livelihood source. Many more people relied on agriculture and fishing for their secondary livelihood sources. Food security based on the water resource was thus strongly linked to livelihoods. Any threats or significant alterations to the Tonle Sap hydrological system (e.g. through hydropower development upstream or climate change) would have far reaching implications for local livelihoods and could lead to increased food insecurity and vulnerability not only locally but across Cambodia.

1.4. Karlberg et al. (2015): Lake Tana Sub-basin, Blue Nile, Ethiopia

1.4.1. Approach

Ethiopia is pursuing an ambitious policy-led agenda of agricultural development through intensification and industrialization, including rapid expansion of irrigation. It is also aiming for an energy transition from traditional biomass to electricity, based on hydropower development. The study takes a national approach to the food-energy-environment nexus of the Lake area in term of policy, but links this to livelihoods and household dimensions at local scale. The nexus approach could be useful in identifying and assessing potential conflicts between these sectoral goals by analysing cross-sectoral interlinkages and competing resource use between the nexus dimensions. The overall research approach was based on participatory stakeholder engagement with scientists, to jointly and systematically analyse the nexus interlinkages and three future development trajectories (scenarios) for the region: Business-as-usual (BAU), National Plans, and Nexus. The analysis focused on 1) agricultural intensification and transformation, and 2) energy systems transition, and related environmental impacts. Initial narratives or qualitative scenarios were developed using a Story And Simulation (SAS) approach and translated into quantitative scenarios which were then analysed using the SEI's nexus toolkit in an iterative process. The toolkit combined the WEAP and LEAP analytical tools. Livelihoods were not formally analysed but were linked into the participatory scenario analysis.

1.4.2. How the nexus is interlinked with livelihoods

The analysis demonstrated how agricultural transformation and energy transitions were interdependent and partially competitive for the same resources. Agricultural intensification required more energy, and crop production remained important for the provision of biomass for energy. Water was needed for the agricultural transformation and for hydropower generation, but was also required for sustained ecosystem services, with the available resources not always meeting all these demands. These tensions had multiple impacts on local livelihoods and livelihood development opportunities.

Under the three development pathways, food and energy production were differentially impacted, with differing levels of related environmental disturbances. The primary environmental impact was on the low water levels of Lake Tana during the dry season. Both the BAU and National Plans scenarios compromised the goal of maintaining the water level in Lake Tana above a minimum level but ensured high hydropower output. While food production was maximized in the Nexus scenario compared to the other two scenarios, hydropower production was substantially lower to maintain the Lake Tana water level. Given the enormous importance of food production and year-round minimum water level for a diversity of livelihood strategies in the area, the study showed how a nexus approach can yield balanced outcomes which support local livelihoods.

Under the Nexus scenario, the construction of irrigation dams facilitated the harvesting of a second or third crop for farmers and provided opportunities for greater cash crop production. Enough additional electricity was available to produce fertilizer, pump irrigation water, and use mechanized cultivation practices, which boosted production (thus increasing food security and incomes). Simultaneously, maintenance of the lake water level above the critical minimum allowed for year-round navigation, fishing, the growing tourism industry and the livelihoods of the Negede people who are based around constructing boats and baskets from papyrus. Under the BAU and National Plans scenarios, the water level was below the critical minimum level for two to three months of the year, thus compromising these lake-dependent livelihoods. Further examples were provided for the interlinkages between biomass production and use, and the agricultural and energy transitions. The high dependence of households on traditional biomass energy was important in this regard.

1.4.3. Strengths and weaknesses in linking nexus and livelihoods approach

Since the study did not explicitly link the nexus and livelihood approaches, the following assessment is based only on the perceived utility of the nexus approach in a local livelihoods context. The strength of this work lies in the participatory scenario-based nexus analysis feeding into the nexus tool-based quantitative analysis, with feedbacks allowing for testing and validation of assumptions and refinement of data and analysis. The approach was very suited to illustrating system-wide and cross-sectoral outcomes of different development policies. However, although the study was able to surface the relevance to resource-based livelihoods in general terms, the study aims and methods did not allow for an in-depth analysis at household and livelihood level. A parallel study by Stein (2013) used social network analysis to identify the stakeholder networks and relationships in the Lake Tana region but focused on actors in decision-making positions. Additional analysis would be required to gain an understanding of the implications of the three scenarios for livelihoods.

1.4.4. How livelihoods impact on the WEF nexus

Livelihood systems were almost entirely dependent on land, water, forests and biodiversity, and poverty rates were very high. Consequently, the region suffered from severe pressure on the natural resource base, linked to land and wetland degradation, siltation of the lake, water scarcity, overfishing, overgrazing, deforestation and other pressures on biomass for fuel, together with a high population growth rate. Alternative livelihood options and a more diversified livelihood system would relieve this pressure and allow for resources to be used more sustainably and productively.

1.4.5. How challenges in the WEF nexus impact livelihoods

Resource supply vulnerabilities are high in the region. Policy decisions around water use for irrigation and hydropower will have impacts on livelihoods based on farming and fishing and other activities on the lake. Under some nexus-relevant policy scenarios, farming livelihoods could be strengthened but at a cost to lake-based livelihoods and environmental goals. Under a scenario where the maintenance of the minimum lake water level is prioritized, a range of existing livelihoods could be protected, and additional livelihood outcomes achieved in the agricultural sector.

APPENDIX 2: Household Questionnaires

Velddrif (Noordhoek)

Water Energy Food Nexus Questionnaire

We, the University of Cape Town are carrying out a questionnaire which forms part of a larger research project that examines the interplay between the life-sustaining resources of water, energy and food (WEF Nexus) at a household level. The aim of the project is to establish how this nexus impacts on livelihoods and wellbeing at both a household and community level. This project is working in three catchments across the country, the Berg River catchment being one of these. In the Berg catchment, the project is working in two sites, namely in the Velddrif area, as well as in the Pniel area. The other two catchments involved in the study are the Keiskamma catchment in the uMngeni and the Eastern Cape in KwaZulu-Natal. The project is funded by the national Water Research Commission.

The aim of this questionnaire is to improve our understanding of household energy, water and/or food insecurities and their impacts on the household (primary focus on access to these resources).

Before completing the questionnaire, we would like you to read and sign the **Informed Voluntary Consent to Participate in Research Study.** Please note that your participation in this study is completely voluntary. You can decline to participate, and you can withdraw at any time.

If you have any questions about this questionnaire, please contact Penny Price, who is the researcher in the Velddrif area on 083 571 3371.

Thank you for taking the time to complete in this questionnaire jointly with me. It should only take an hour of your time.

Section A: General Information

Interviewer Details

Questionnaire No.	
Student Name	Penny Price
Interviewer Name	

Location Details

Site	Velddrif
District	West Coast
Municipality	Bergrivier
Suburb/Ward/Village	Noordhoek
Street address	

Interviewee Details

Name of person being interviewed ____________________

Contact Number: ____________________

Type of Building Structure *(Mark both building structure and type of dwelling)*

Select one:		**Select one:**	
Brick and mortar	☐	Main house	☐
Wood	☐	Backyard dwelling	☐
Zinc	☐		
Other	☐	Specify: __________	

A1. How many years have you been living here? *(Mark relevant box with a x)*

0-2 years	☐	11-20 years	☐
3-10 years	☐	20+ years	☐

A2 Details of household members

Household Members	Gender		Age	Head of Household	Relationship Interviewee	Student	Source of Income		
	M	F		(Y/N)		(Y/N)	Salary	Grant	Other
Person 1									
Person 2									
Person 4									
Person 5									
Person 6									
Person 7									
Person 8									
Person 9									
Total in Household									

Age Categories:

Adults	61 & older	Youth	31-35	Children	10-12
	51-60		26-30		6-9
	41-50		19-25		2-5
	36-40		13-18		0-2

A3 Household members income and employment

Household Members	Employment Time		Employment Type				Employment Details			Previous Employment
	Full Time	Part Time	Permanent	Contract	Seasonal	Casual	Sector	Role	Duration (how long)	Details
Person 1										
Person 2										
Person 4										
Person 5										
Person 6										
Person 7										
Person 8										
Person 9										

Explanation Notes:

Full Time	*40 to 45 hours a week*
Part Time	*Less than 40 hours a week*
Seasonal	*Having employment for a seasonal period, e.g. in autumn for harvest.*
Casual	*Having employment on an ad hoc basis, nothing regular or planned, but as the employer sees the need on a day to day basis.*
Sector	*e.g. building, retail, engineering, municipality, agriculture, fishing, etc.*
Role	*e.g.* labourer, driver, cleaner, manager, own business, etc.

A4. Does your household receive any of the following municipal services? *(Mark relevant answers with a x)*

Electricity	☐	Refuse removal	☐
Water	☐	Sewerage	☐

A4.1. If yes, how would you rate the reliability of the municipal services in terms of water and electricity supply in your neighbourhood? *(Mark relevant answers with a x)*

	Water	Electricity	Refuse Removal	Sewerage
Reliable *(always available except for maintenance or rare accident)*				
Unreliable *(lack of supply which leads to significant disruption of household activities)*				

A5. Does your household use local natural resources/environment *(e.g. river, estuary, beach)* for meeting the household water energy and food needs? *(Write down detail of resource use)*

	Food *(e.g. fishing)*	Energy *(e.g. collecting wood)*	Water *(e.g. washing clothes)*
River			
Estuary			
Beach			
Ocean			
Other			

A6. What are the biggest challenges that your household is facing at the moment? (*List all that applies)*

Section B. Water

W1. Are you always able to meet your water demands?
Yes ☐ No ☐

W1.1 If no, is it:
Regularly ☐ Sometimes ☐ Hardly ever ☐

W2. What is your household's main source of drinking water? *(Mark relevant answers with x)*

Piped (tap) water in house	☐	Borehole water in yard	☐
Piped (tap) water in yard	☐	Borehole outside yard	☐
Rain-water tank in yard	☐	Public/communal tap	☐
Neighbour's tap	☐	Well point	☐
Inside main house (if backyarder)	☐		

Other, specify ____

W2.1 How far is the water source indicated above from the house / dwelling? *(Mark relevant answers with x)*

Inside the house	☐	Less than 200 metres	☐
Inside the yard/plot	☐	Do not know	☐

W2.2 What is the quality of your main source of drinking water (before you have treated it)? *(Mark relevant answers with a x)*

	Yes	No
Safe to drink?	☐	☐
Looks bad (colour)	☐	☐
Taste bad	☐	☐
Smells bad	☐	☐

W2.3 If your main source of drinking water looks, tastes or smells bad, what do you do? *(Mark relevant answers with x)*

Nothing	☐
Use an alternative source (e.g. buy water)	☐
Treat the water at home (e.g. boiling or filtering)	☐

Other, specify ____

W3. Please list the main water source for all other household uses in the table below:

Activities	Sources
Washing clothes	
Bathing/ washing	
Cleaning the house	
Home business use	
Watering the garden	
Watering livestock *(e.g. chickens)*	

W4. What type of toilet facility does this household have? *(Mark relevant answers with a x)*

Flush toilet inside ☐ Communal flush toilet ☐
Flush toilet outside ☐ Other, within house premises ☐

W5. When you can't meet your water needs what measures do you take? *(Mark relevant answers with x)*

Ask neighbours for help ☐

Other, specify ____

W6. Do local environmental issues (such as groundwater depletion, water pollution, drought, flooding) impact the availability and quality of water in your household? *(Mark relevant answers with a x)*

Yes ☐ No ☐

W6.1 If yes please specify:

	Water Quality	Water Quantity
Water Pollution		
Drought		
Flooding		
Ground Water Depletion		
Other, Specify		

W7. Is the availability and quality of water in your household negatively impacted by poor government service delivery? *(If yes, mark relevant answers with a x)*

Water Quality: Yes ☐ No ☐
Water Quantity: Yes ☐ No ☐

W8. If water quality is a recurring problem in your area, please specify the impacts this has on the following:

Area	Specify Impact
Your household *(e.g. drinking water)*	
Your home-based business *(e.g. catering)*	
Your workplace outside the home	

W9. If water shortage is a recurring problem in your area, please specify the impact this has on the following:

Area	Specify Impact
Your household *(e.g. drinking water)*	
Your home-based business *(e.g. catering)*	
Your workplace outside the home	

W10. In the x years you have been living in this community has your household access to water:

Improved ☐
Stayed the same ☐
Declined ☐

W11. In the x years you have been living in this community has your household affordability of water:

Improved ☐
Stayed the same ☐
Declined ☐

W12. In the x years you have been living in this community has your household water quality:

Improved ☐
Stayed the same ☐
Declined ☐

W13. Do you take any measures to save water?

Yes □ No □

W13.1 If yes, can you list them?

W14. What would help you in terms of water security?

Section C. Energy

E1. What types of energy sources do you currently use and approximately how much does each cost per week? *(You can give answer in monthly terms if the respondent prefers)*

	Use	Estimated cost/week	Estimated cost/month
Electricity	Yes ☐ No ☐		
Gas	Yes ☐ No ☐		
Paraffin	Yes ☐ No ☐		
Fuelwood	Yes ☐ No ☐		
Petrol/diesel for generator	Yes ☐ No ☐		
Other, specify			

E1.1 Please specify the sources for each household energy use activities:

Household Energy Use Activities	Sources of Energy
Cooking	
Lights	
Appliances *(TV, kettle, microwave, fridge, etc.)*	
Water heating for bathing	
Water heating for washing dishes	
Laundry *(washing clothes)*	
Household heating	
Home-based business activities	
Others	

E2. Are you always able to meet your energy demands?
Yes ☐ No ☐

E2.1 If no, is it:
Regularly ☐ Sometimes ☐ Hardly ever ☐

E3. What measures do you take when you can't meet your energy needs?

E4. Do you use renewable energy sources *(e.g. solar energy, wind power, biogas)* for your household? *(Mark relevant answers with x)*

Yes ☐ No ☐

If yes, for what purpose? *(list purpose for each identified renewable energy source)*

Renewable Energy Sources	Purpose

E5. Is electricity service provision a recurring problem in your area? *(Mark relevant answers with x)*

Yes ☐ No ☐

E5.1. If yes, please specify the reasons. *(Mark relevant answers with a x)*

Unreliable service provision by the municipality ☐
Unreliable service provision by Eskom ☐
Cost of electricity provision is too high for our household ☐

Other, specify ____

E5.2 If yes, please specify how / if it impacts you in the following areas:

Area	Specify Impact
Your household *(e.g. lighting or cooking)*	
Your home-based business *(e.g. catering)*	
Your workplace outside the home *(i.e. at work)*	

E6. In the x years you have been living in this community has the access to household electricity:

Improved ☐ Stayed the same ☐ Declined ☐

E7. In the x years you have been living in this community has the affordability of household electricity:

Improved ☐ Stayed the same ☐ Declined ☐

E8. Do you take any measures to save electricity?

Yes ☐ No ☐

E8.1 If yes, can you list them?

____

____

____

____

____

____

____

____

____

____

E9. What would help you in terms of energy security? *(i.e. consistently meeting your energy needs to an affordable price)*

____

____

____

____

____

____

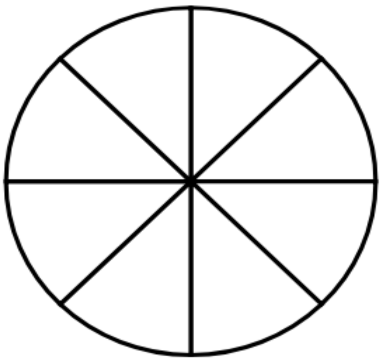
____

Section D. Food

F1. What regular food items are included in your weekly household 'food basket'?
(Food basket is the food that is typically in your house for a week, can be bought, grown, caught, bartered, etc.)

Food Category	Balanced Food Basket *(for low income consumers)*	Additional Items
Starch-rich staple foods	Maize meal, brown bread, white bread, rice, potatoes and wheat flour;	
Animal protein foods	Beef mince, chicken pieces, canned pilchards, eggs, polony and sausage;	
Vegetables	Tomatoes, onions, carrots, cabbage and pumpkin;	
Fruit	Apples, bananas and oranges;	
Dairy	Full cream milk, sour milk / maas and cheddar cheese;	
Fats & oils	Sunflower oil, margarine and peanut butter;	
Sugary foods	White sugar	
Legumes	Dried beans and baked beans in tomato sauce	

F2. If you think of your weekly household income as a pie, how much of the pie gets used up on food expenses? Indicate what category the remainder is spent on *(i.e. electricity, transport, school, debt, education, rent, clothes, etc.)*



Other Main Expenses:

F3. Do you grow your own vegetables/ fruit to help to meet the food needs of the household?

Yes ☐ No ☐

F3.1 If yes, what are the sources of water used?

F3.2 If no, please specify the reasons with an x:

No access to land	☐	No money to buy seeds/ plants	☐
No access to water	☐	No interest	☐
Poor soil quality	☐	No time	☐
Security issues	☐		

Other, specify

F4. Do you keep any animals to help meet the food needs of your household *(e.g. chickens)*

Yes ☐ No ☐

F4.1 If yes, please specify what animals

F5. Do you fish to supplement your weekly household food needs?

Regularly ☐ Sometimes ☐ Never ☐

F6. Do you harvest any wild fruit or vegetables to supplement your weekly food needs of the household *(e.g. veldkos)*?

Regularly ☐ Sometimes ☐ Never ☐

F7. Do you hunt to supplement your weekly household food needs?

Regularly ☐ Sometimes ☐ Never ☐

F8. Please indicate where the food items that you buy/ purchase each week come from:

	Bread	Meat	Milk / diary	Cereal	Canned food	Eggs	Vegetables	Fruit
Supermarket								
Corner shop /spaza shop								
Street trader								
Local farmer/ neighbour								
Other, specify								

F9. Does the household receive food aid *(food parcels)*?

Yes ☐ No ☐

F9.1 If yes, from where?

____

____

F9.2 If yes, when did the household last received food aid?

Within the last month ☐ Within the last 6 months ☐
Within the last 3 months ☐ Within the last 12 months ☐

F10. Reflecting on the past x years would you say the affordability of food has:

Improved ☐ Stayed the same ☐ Declined ☐

F11. Reflecting on the past x years the diversity of your weekly household food basket (includes bread, milk, fruit, vegetables, meat, etc.) has:

Improved ☐ Stayed the same ☐ Declined ☐

F12. Do you take measures to provide your household with nutritious food at an affordable price?

Yes ☐ No ☐

F12.1 If yes, would you please list them?

F13 What would help you in terms of food security?

Pniel & Lanquedoc

Water Energy Food Nexus Questionnaire

One-page overview

We, the African Climate and Development Initiative and the University of Cape Town, are carrying out a questionnaire which forms part of a larger research project that examines the interplay between the life-sustaining resources of water, energy and food (WEF Nexus) at a household level. The aim of the project is to establish how this nexus impacts on livelihoods and wellbeing at both a household and community level. This project is working in three catchments across the country, the Berg River being one of these. In the Berg River catchment, the project is working in two sites, namely in the Pniel/Lanquedoc area, as well as in the Velddrif area. The other two catchments involved in the study are the Umngeni catchment in KwaZulu-Natal and the Keiskamma catchment in the Eastern Cape. The project is funded by the national Water Research Commission.

The aim of this questionnaire is to improve our understanding of household energy, water and/or food insecurities and their impacts on the household (primary focus on access to these resources).

Before completing the questionnaire, we would like you to read and sign the **Informed Voluntary Consent to Participate in Research Study.** Please note that your participation in this study is completely voluntary. You can decline to participate, and you can withdraw at any time.

If you have any questions about this questionnaire, please contact:

- Nadine Methner (project leader) – 079 282 9316
- Vumande Mjanyelwa (student in Pniel/Lanquedoc area) – 072 3481 873
- Penny Price (youth programme manager) – 083 571 3371

Thank you for taking the time to complete in this questionnaire jointly with me. It should only take **60 minutes of your time**.

Section A: General Information

Interviewer Details

Questionnaire No. ____________________

Student Name ____________________

Interviewer Name ____________________

Location Details

Site _______

District _______

Municipality _______

Suburb/Ward/Village _______

Street address _______

GPS code from Smart Phone ____________________

Type of Building Structure

Brick and mortar ◻
Mud ◻
Wood ◻
Zinc ◻
Main house ◻
Backyard dwelling ◻

Person Interviewed Details

Name ____________________

Age 20-30 ◻ 31-40 ◻ 41-50 ◻ 51-60 ◻ Above 61 ◻

Gender
Male ◻
Female ◻
Other ◻

Contact phone number ____________________

Household Head Details (if other than interviewee)

Name ____

Age 20-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ Above 61 ☐

Gender

Male ☐

Female ☐

Other ☐

A1. How many years have you been living here? *(Mark relevant answers with a x)*

0-2 years	□
3-10 years	□
11-20 years	□
20+ years	□

A2. How many people live in this household? *(Indicate the number of males and females members in the relevant box, e.g. 1 or 3)*

Total number of people □

	Male Total	□	**Female Total**	□
Adults	61 and older	□	61 and older	□
	51-60	□	51-60	□
	41-50	□	41-50	□
	36-40	□	36-40	□
Youth	31-35	□	31-35	□
	26-30	□	26-30	□
	19-25	□	19-25	□
Children	13-18	□	13-18	□
	10-12	□	10-12	□
	6-9	□	6-9	□
	2-5	□	2-5	□
	0-2	□	0-2	□

A3. How many household members contribute financially to the household income on a regular basis?

____

A4. What are the major sources of income for the household? *(Tick the appropriate boxes, where M denotes Male and F denotes Female)*

Household Members	Major Source of Income	Other Sources of Income
Person 1 M □ F □		
Person 2 M □ F □		
Person 3 M □ F □		
Person 4 M □ F □		
Person 5 M □ F □		

A5. What sectors do the household members work in? *(Fill in details for roles and sectors and mark relevant boxes for permanent, contract, seasonal and casual)*

Household Members	Role	Sector (site relevant sectors to be listed by masters based on IDPs or census data)	Permanent	Contract	Seasonal	Casual
Full Time ◻ Part Time ◻						
Full Time ◻ Part Time ◻						
Full Time ◻ Part Time ◻						
Full Time ◻ Part Time ◻						
Full Time ◻ Part Time ◻						

Description

Full-time: 40 to 45 hours a week Part-
time: less than 40 hours a week
Casual employment: having employment on an ad hoc basis, nothing regular or planned, but as the employer sees the need on a day to day basis.
Seasonal work: having employment for a seasonal period, e.g. in autumn for harvest.

A6. Does your household receive any of the following municipal services? *(Mark relevant answers with a x)*

Electricity ◻
Water ◻
Refuse removal ◻
Sewerage ◻

A7. If yes, how would you rate the reliability of the municipal services in terms of water and electricity supply in your neighbourhood? *(Mark relevant answers with a x)*

	Water	**Electricity**
Reliable	◻	◻
Unreliable	◻	◻

Description

Reliable: always available except for once of a maintenance or accident.
Unreliable: lack of supply which leads to significant disruption of household activities

A8. Does your household use local natural resources/environment (e.g. rivers/forest/estuary) for meeting the household water energy and food needs? *(Mark relevant answers with a x) write down the detailed answers.*

Natural Resources	Water (e.g. washing clothes)	Energy (e.g. collecting wood)	Food (e.g. fishing)
River			
Forest/bush			
Estuary			
Ocean			
Other			

A9. What are the biggest challenges that your household is facing at the moment? e.g. family health, children education. *(list all that applies)*

Section B. Water

W1. Please select the statement that is most relevant for your household *(Mark relevant answers with a x):*

- □ We frequently need to ration our water and make conscious decision for which activities we can use
- □ We have to walk long distances to meet our water demands
- □ We have to spend a lot of our time to meet our water demands
- □ We have to use a lot of our monthly income to meet our water demands
- □ We are always able to meet our water demands
- □ We sometimes are unable to meet our water needs.
- □ We regularly are unable to meet our water needs.

W2. What is your household's main source of drinking water? *(Mark relevant answers with a x)*

Piped (tap) water in house	□
Piped (tap) water in yard	□
Borehole water in yard	□
Rain-water tank in yard	□
Neighbour's tap	□
Public/communal tap	□
Water-carrier/tanker	□
Borehole outside yard	□
Water from stream/river	□
Water from dam/pool	□
Well	□
Spring small streams in season	□

Other, specify ____

W2.1 How far is the water source indicated above from the house / dwelling? *(Mark relevant answers with a x)*

Inside the house	□
Inside the yard/plot	□
Less than 200 metres	□
201-500 metres	□
501 metres-1 kilometre	□
More than 1 kilometre	□
Do not know	□

W2.2 What is the state of the main source of drinking water before any treatment? *(Mark relevant answers with a x)*

	Yes	**No**
Safe to drink?	□	□
Looks bad (colour)	□	□
Taste bad	□	□
Smells bad	□	□

W3. Please list the main water source for all other household uses in the table below:

Activities	**Sources**
Washing clothes	
Bathing/ washing	
Watering the garden/crops	
Watering livestock	
Home business use	
Cleaning the house	
Cooking	

W4. What type of toilet facility does this household have? *(Mark relevant answers with a x)*

Flush toilet ◻
Other, within house premises ◻
Communal (outside house premises) ◻

W5. When you can't meet your water needs what measures do you take? *(Mark relevant answers with a x)*

Ask neighbours for help ◻
Other, specify ____

W6. Do local environmental issues (such as groundwater depletion, water pollution, drought, flooding) impact the availability and quality of water in your household? *(Mark relevant answers with a x)*

Yes ◻
No ◻

W6.1 If yes please specify:

Water Quality		Water Quantity
Ground water depletion	◻	◻
Water pollution	◻	◻
Drought	◻	◻
Flooding	◻	◻

Other, specify ____

W7. Is the availability and quality of water in your household negatively impacted by poor government service delivery? *(If yes, mark relevant answers with a x)*

	Water Quality		Water Quantity
Yes	◻	◻	◻
No	◻		

W8. If water quality is a re-occurring problem in your area, please specify and rank below how it impacts: (0-2 with 0=no impact and 2 highest impact)

Area	**Specify Impact**	**Rank (0-2)**
Your household (e.g. drinking water)		
Your home-based business (e.g. catering)		
Your workplace outside the home		

W9. If water shortage is a re-occurring problem in your area, please specify and rank below how it impacts: (0-2 with 0=no impact and 2 highest impact)

Area	**Specify Impact**	**Rank (0-2)**
Your household (e.g. drinking water)		
Your home-based business (e.g. catering)		
Your workplace outside the home		

W10. In the____years you have been living in this community has your household access to water:

Improved □
Stayed the same □
Declined □

W11. In the_____years you have been living in this community has your household affordability of water:

Improved □
Stayed the same □
Declined □

W12. In the____years you have been living in this community has your household water quality:

Improved □
Stayed the same □
Declined □

W13. What would help you to become more water secure, to meet your household's needs?

____

____

____

____

____

Section C. Energy

E1. What types of energy sources do you currently use?

Type of energy source (tick all that are used)

- Electricity ◻
- Paraffin ◻
- Gas ◻
- Fuelwood ◻
- Manure ◻
- Crop Residue ◻
- Petrol/ diesel for generator ◻
- Other, specify ____________________

Please specify the sources for each household energy use activities as well as the estimated cost per week:

Household Energy Use Activities	**Sources of Energy**	**Estimated Cost per Week**
Cooking		
Lights		
Appliances (TV, kettle, microwave, fridge, etc.)		
Water heating for bathing		
Water heating for washing dishes		
Laundry (washing clothes)		
Household heating		
Household related farming activities		
Home-based business activities		
Others		

E2. Please select the statement that is most relevant for your household:

- ◻ We frequently need to ration our energy & make conscious decision for which activities we can use
- ◻ We have to walk long distances to meet our energy demands
- ◻ We have to spend a lot of our time in meet our energy demands
- ◻ We have to use a lot of our monthly income to meet our energy demands
- ◻ We are always able to meet our energy demands
- ◻ We sometimes are unable to meet our energy needs.
- ◻ We regularly are unable to meet our energy needs

E3. Do you use renewable energy sources (e.g. solar energy, hydropower, biogas) for your household? *(Mark relevant answers with a x)*

Yes ◻
No ◻

If yes, for what purpose? *(list down for each identified renewable energy source)*

Renewable Energy Sources	**Purpose**

E4. What measures do you take when you can't meet your energy needs?

____

____

____

____

E5. Do you get electricity from the national grid? *(If no, move to question no.8)*

Yes ◻
No ◻

E5.1. If yes, is electricity service provision a re-occurring problem in your area? *(Mark relevant answers with a x)*

Yes ◻
No ◻

E5.1.1 If yes, please specify the reasons. *(Mark relevant answers with a x)*

Unreliable service provision by the municipality ◻
Unreliable service provision by Eskom ◻
Cost of electricity provision is too high for our household ◻
Other, specify ____

E5.2 If yes, please mark and rank below how it impacts you (0-2 with 0=no impact and 2 highest impact)

Area	**Specify Impact**	**Rank (0-2)**
Your household (e.g. drinking water)		
Your home-based business (e.g. catering)		
Your workplace outside the home		

E6. In the____years you have been living in this community has the access to household electricity:

Improved ◻
Stayed the same ◻
Declined ◻

E7. In the____years you have been living in this community has the affordability/cost of household electricity:

Improved ◻
Stayed the same ◻
Declined ◻

E8. What would help you to become more energy secure, which means meeting consistently your energy needs to an affordable price?

____

____

____

____

____

____

Section D. Food

F1. What regular food items are included in your weekly household 'food basket'? *(List down all that applies)*

____

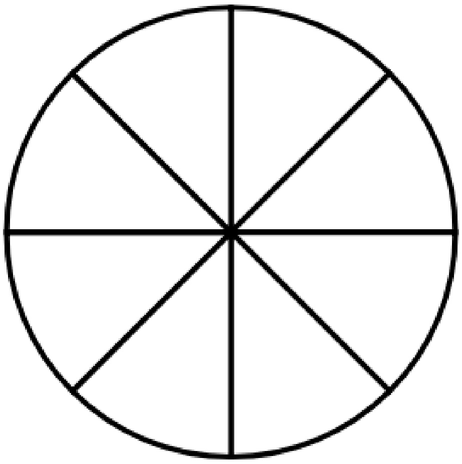
____

____

____

____

F2. If you think of your weekly household income as a cake, how much of the cake gets used up on food expenses?



F3. Do you grow your own vegetables/ fruit to help to meet the food needs of the household?

Yes □
No □

F3.1 If yes, what are the sources of water used?

____

____

F3.2 If no, please specify the reasons with an x:

No access to land □
No access to water □
Poor soil quality □
No money to buy seeds/ plants □
No interest □
No time □
Security issues □

Other, specify ______________________________

F4. Do you harvest any wild fruit or vegetables to supplement your weekly food needs of the household?

Regularly □
Sometimes □
Never □

F5. Do you hunt to supplement your weekly household food needs?

Regularly □
Sometimes □
Never □

F6. Do you fish to supplement your weekly household food needs?

Regularly □
Sometimes □
Never □

F7. Please check where the food items that you buy/ purchase each week come from:

0 = none
1 = some
2 = all

	Fruit	**Vegetable**	**Meat**	**Cereal**	**Canned food**	**Milk**	**Eggs**	**Bread**
Supermarket								
Corner shop/spaza shop								
Street trader								
Local farmer/ neighbour								
Other, specify								

F8. Does the household receive food aid (food parcel)?

Yes □
No □

F8.1 If yes, from where?

____
____
____

F8.2 If Yes, when did the household last received food aid?

Within the last month □
Within the last 3 months □
Within the last 6 months □
Within the last 12 months □

F9. Reflecting on the past____years would you say the affordability of food has:

Improved ◻
Stayed the same ◻
Declined ◻

F10. Reflecting on the past____years the diversity of your weekly household food basket (includes bread, milk, fruit, vegetables, meat, etc) has:

Improved ◻
Stayed the same ◻
Declined ◻

F11. What are the biggest challenges in providing your household with nutritious food (at an affordable price)?

____

____

____

____

____

____

F12. Household Food Insecurity Access Scale (HFIAS)

NO	QUESTION	RESPONSE OPTIONS	CODE
1.	In the past four weeks, did you worry that your household would not have enough food?	0 = No (skip to Q2) 1=Yes	
1.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
2.	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	0 = No (skip to Q3) 1=Yes	

2.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
3.	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	0 = No (skip to Q4) 1 = Yes	
3.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
4.	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	0 = No (skip to Q5) 1 = Yes	
4.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
5.	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0 = No (skip to Q6) 1 = Yes	
5.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
6.	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	0 = No (skip to Q7) 1 = Yes	

6.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
7.	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	0 = No (skip to Q8) 1 = Yes	
7.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
8.	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	0 = No (skip to Q9) 1 = Yes	
8.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
9.	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	0 = No (questionnaire is finished) 1 = Yes	
9.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	

Glossary

FOOD SECURITY "is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2002, p. 49).

Dimensions of food security:

- food availability
- access
- stability of supply
- utilization

ENERGY SECURITY is defined by the International Energy Agency (IEA) as "the uninterrupted availability of energy to an affordable price"

Dimensions of energy security as defined by Sovacool and Brown (2010):

- availability
- affordability
- efficiency
- environmental stewardship

WATER SECURITY "refers to the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies". (Grey and Sadoff, 2007: 545)

The **WATER ENERGY FOOD NEXUS:** describes the interrelationships, synergies and tradeoffs between water, energy and food demands and between the natural resources that support these sectors.

References

- FAO, 2002. The State of Food Insecurity in the World 2001. Food and Agriculture Organization, Rome.
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- Sovacool, B.K., Brown, M.A., 2010. Competing dimensions of energy security: an international perspective. Annu. Rev. Environ. Resour. 35 (1), 77-108. http://dx.doi.org/ 10.1146/annurev-environ-042509-143035
- The International Energy Agency (IEA), Source: http://www.iea.org/topics/energysecurity Accessed May 2017

<u>**Melani & Hamburg**</u>

QUESTIONNAIRE
FACULTY OF SCIENCE AND AGRICULTURE
DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

QUESTIONNAIRE ON WELFARE IMPLICATIONS OF THE WATER-ENERGY-FOOD NEXUS AT HOUSEHOLD LEVEL: A CASE OF HAMBURG AND MELANI COMMUNITIES IN THE EASTERN CAPE PROVINCE SOUTH AFRICA

Please be aware that all the information provided here will be treated as STRICTLY CONFIDENTIAL.

The aim of this questionnaire is to improve our understanding of household energy, water and food insecurities and their impacts on the household (primary focus on access to these resources).

If you have any questions about this questionnaire, please contact [Mr Thulani Ningi, Masters Student, 0847044123].

Thank you for taking the time to complete this questionnaire jointly with me. It should only take 15 minutes of your time.

Section A: General Information

Interviewer Details

Questionnaire No. ____________________

Student Name ____________________

Interviewer Name ____________________

Location Details

Site ____________________

District ____________________

Municipality ____________________

Suburb/Ward/Village ____________________

GPS code from Smart Phone ____________________

A1. Socio economic characteristics of the household.

No	Socio-economic Characteristics	Responses	Codes for Options
1.1	Gender		**0** = Male, **1**= Female
1.2	Age(Years)		Write your age (or year of birth)
1.3	Marital Status		**0** = unmarried/single, **1**= Married
1.4	Household size		Total no of people living and eating together in the household
1.4.1.	Please indicate the number of people living in your household within each age group below	**Number A+B+C+D = 1.5**	
a	0-15 years		Write actual number (e.g. 2, 3, 4, etc.)
b	16-40 years		Write actual number (e.g. 2, 3, 4, etc.)
c	41-65years		Write actual number (e.g. 2, 3, 4, etc.)
d	Above 65 years		Write actual number (e.g. 2, 3, 4, etc.)
1.5	Highest Educational Qualification attained		**0** = No formal education;**1**=Primary education;**2**= Secondary education **3** = Tertiary education
1.6	Pick the main source of income if you are engaged in more than one of the options listed.		**0**= Agricultural activities;**1**=Salaried employment;**2**=Trading/Business;**3**=Social grants e.g. child support , foster care, old age; disability ; **4**=Remittances; 5=Other (Specify)………………..
1.7	Which of the following best describes your household monthly income?		**0**= < R500;**1** = R500-R1000; **2** = R1001-R2,000;**3** = R2,001-R5,000; **4** = R5,001-R10,000; **5** = R10,001-R20,000; **6** = R20,001-R30,000 **7** = R30.001-R50,000; **8** = >50,000
1.8	Employment Status		**0**=Unemployed;**1**= Employed
1.9	Race		0 =black; 1=if white; 2=other.

SECTION B: WATER STATUS

B2. Which of the following sources of drinking water are available in your neighbourhood? *(Mark relevant answers with an x)*

Piped (tap) water in house ☐
Piped (tap) water in yard ☐
Borehole water in yard ☐
Rain-water tank in yard ☐
Neighbour's tap ☐
Public/communal tap ☐
Water-carrier/tanker ☐
Borehole outside yard ☐
Water from stream/river ☐
Water from dam/pool ☐
Well ☐
Spring small streams in season ☐

Other, specify ______________________________________

B2.1.What is your household's main source of drinking water? *(Mark relevant answers with an x)*

Piped (tap) water in house ☐
Piped (tap) water in yard ☐
Borehole water in yard ☐
Rain-water tank in yard ☐
Neighbour's tap ☐
Public/communal tap ☐
Water-carrier/tanker ☐
Borehole outside yard ☐
Water from stream/river ☐
Water from dam/pool ☐
Well ☐
Spring small streams in season ☐
Other, specify ______________________________________

B3. How far is the water source indicated above from the house / dwelling? *(Mark relevant answers with an x)*

Inside the house ☐
Inside the yard/plot ☐
Less than 200 metres ☐
201-500 metres ☐
501 metres-1 kilometre ☐
More than 1 kilometre ☐
Do not know ☐

B4. How many times per week do you have access to water in your household?
Once ☐
Twice ☐
More than two ☐

B5. How long does it take you to collect water from the source?
30 minutes ☐
1 Hour ☐
2 or more hours ☐

B6. Do you pay any fees for water or water related services?
Yes ☐
No ☐
B6.1. If yes in 5, how much per month? R……………………….
B6.2. If you pay for water, would you say water is affordable?
Yes ☐
No ☐

B7. What type of toilet facility does this household have? *(Mark relevant answers with an x)*

Flush toilet ☐
Other, within house premises ☐

B8. Have you experienced water shortages in past one year?
Yes ☐
No ☐
B9. When you can't meet your water needs what measures do you take? *(Mark relevant answers with an x)*
Ask neighbours for help ☐
Other, specify ____________________________________
B10. When water is not available in your household, do you spend a lot of time looking for water?
Yes ☐
No ☐
B11. Please rate the extent to which you agree with the following statements pertaining to water access to your household (Tick appropriate box).

	Strongly disagree=1	**Disagree=2**	**Neutral=3**	**Agree=4**	**Strongly agree=5**
We frequently need to ration our water and make conscious decision for which activities we can use					
We have to walk long distances to meet our water demands					
We have to spend a lot of our time to meet our water demands					
We have to use a lot of our monthly income to meet our water demands					
We are always able to meet our water demands					
We sometimes are unable to meet our water needs.					
We regularly are unable to meet our water needs.					
We always get water in our household					
Water is sufficient for our household Requirements					
We are satisfied with the water we receive in our household					
Our right or claim to water is secure					

We have problems with too much water in my household.					

SECTION C: ENERGY STATUS

C1. What types of energy sources do you currently use?

Type of energy source (tick all that are used)

Electricity ☐
Electric stove ☐
Paraffin ☐
Gas ☐
Fuelwood ☐
Manure ☐
Crop Residue ☐
Petrol/ diesel for generator ☐
other, specify ______________________________________

C2. Please specify the sources for each household energy use activities as well as the estimated cost per week:

Household Energy Use Activities	Sources of Energy	Estimated Cost per Week
Cooking		
Lights		
Appliances (TV, kettle, microwave, fridge, etc.)		
Water heating for bathing		
Water heating for washing dishes		
Laundry (washing clothes)		
Household heating		
Household related farming activities		
Home-based business activities		
Others		

C3. Do you use renewable energy sources (e.g. solar energy, hydropower, and biogas) for your household? *(Mark relevant answers with an x)*

Yes ☐
No ☐

C3.1. If yes, for what purpose? *(List down for each identified renewable energy source)*

Renewable Energy Sources	Purpose

C4. What measures do you take when you can't meet your energy needs?

____
____
____

C5. Do you get electricity from the national grid? *(If no, move to question no.6)*

Yes ☐
No ☐

C5.1. If yes, is electricity service provision a re-occurring problem in your area? *(Mark relevant answers with an x)*

Yes ☐
No ☐

C5.2. If yes, please specify the reasons. *(Mark relevant answers with an x)*

Unreliable service provision by the municipality ☐
Unreliable service provision by Eskom ☐
Cost of electricity provision is too high for our household ☐
Other, specify ______________________________________

C5.3. If yes, please mark and rank below how it impacts you (0-2 with 0=no impact and 2 highest impact)

Area	Specify Impact	Rank (0-2)
Your household (e.g. energy for lighting)		
Your home-based business (e.g. catering)		
Your workplace outside the home		

C6. In the x years you have been living in this community has the access to household electricity:

Improved ☐
Declined ☐

C7. In the x years you have been living in this community has the affordability of household electricity:

Improved ☐
Declined ☐

C8. What would help you to become more energy secure, which means meeting consistently your energy needs to an affordable price?

____

SECTION D: FOOD STATUS

D1. Have you experienced drought in recent years in relation to water scarcity? *(Mark relevant answers with an x)*
Yes ☐
No ☐

D2. Is your water infrastructure aging?
Yes ☐
No ☐

D3. Did you use any credit in the last 12 months? Yes ☐ or No ☐

D4. Is your household involved in any kind of farming activities? Yes ☐ or No ☐

D5. Who is the owner of the land and how is it divided?

Household head ☐__________ha
Spouse/wife of head of the household ☐__________ha
Boy child ☐__________ha
Girl child ☐__________ha
Other, specify ☐__________ha

D6. Household Food Insecurity Access Scale (HFIAS).

NO	QUESTION	RESPONSE OPTIONS	
1.	In the past four weeks, did you worry that your household would not have enough food?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
2.	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
3.	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
4.	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
5.	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
6.	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
7.	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	

8.	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	
9.	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	

D7. HOUSEHOLD WATER INSECURITY SCALE

NO	For each item, the question followed the same format ''In the past four weeks, how frequently... .''	Response
1.	Did you worry you would not have enough water for all of your household needs?	
2.	Did you feel angry or frustrated that you would not have enough water for all your household needs?	
3.	Did you worry about the safety of the person getting water for your household?	
4.	Has the time spent fetching water prevented anyone in your household from earning income?	
5.	Has the time spent fetching water prevented you or anyone in your household from caring for your children?	
6.	Has anyone in your household asked to borrow water from other people?	
7.	Has there not been enough water in the household to wash clothes?	
8.	Have you missed meetings in your community (church, funerals, community meetings, etc.) because there wasn't enough water?	
9.	Have you missed meetings in your community (church, funerals, community meetings, etc.) because you lacked water to take a bath and you felt too dirty to go?	
10.	Have you or anyone in your household had to change what was being cooked because there wasn't enough water?	
11.	Did you or anyone in your household had to go without washing hands after defecating, changing diapers or other dirty activities because you didn't have enough water?	
12.	Did you not have enough water to wash your children's face and hands?	
13.	Did you or anyone in your household have to go without washing their body because there wasn't enough water?	
14.	Did you or anyone in your household want to treat your water, but couldn't? By treat I mean boiling, using chemicals to treat, or other ways you make your water safe to use or drink?	
15.	Did you or anyone in your household actually had to drink water that you thought was unsafe?	
16.	Did you have problems with water that caused arguments/trouble with neighbours or others in the community?	
17.	Has there not been as much water to drink, as you would like for you or members of your household?	
18.	Have you or anyone in your household nit had enough water to take medications?	
19.	Have you or anyone in your household gone to sleep thirsty?	
20.	Have you had no water whatsoever in your household?	

Note: for each question, participants were asked to respond to one of the following options; Never= 0, Rarely= 1-2 times prior 4 weeks, sometimes= 3-10 times prior 4 weeks, often= 11-20 times prior 4 weeks, always== above 20 times in prior 4 weeks

APPENDIX 3: Supplemental material to the multi-variate statistical analysis

Table 32 Codes and descriptions used in the multivariate analysis. H = variables relating to households, W = variables relating to water, E = variables relating to energy, and F = variables relating to food.

Code	Description	Details (when binary)	Details (when categorical)
H_AgeHH	Age Household Head		<20, 20-40, 41-60, >60
H_DurRes	Duration of Residence		0-2y, 3-10y, 11-20y, >20y, N/A
H_DwellStruct	Dwelling Structure		Brick, Wood, Zinc, Cement, N/A
H_DwellType	Dwelling Type		Main (main house), Back (backyard dweller), N/A
H_EmplSect_AgricForFish	Employment Sector	Agriculture, Forestry, Fishing Sector	
H_EmplSect_Commercial	Employment Sector	Commercial Sector	
H_EmplSect_Construction	Employment Sector	Construction Sector	
H_EmplSect_Government	Employment Sector	Government Sector	
H_EmplSect_Manufacturing	Employment Sector	Manufacturing Sector	
H_EmplSect_Other	Employment Sector	Other Sector	
H_EmplStatus	Employment Status		Employed, Unemployed
H_EmplType_Casual	Employment Type	Casual	
H_EmplType_Contract	Employment Type	Contract	
H_EmplType_Permanent	Employment Type	Permanent	
H_EmplType_Seasonal	Employment Type	Seasonal	
H_GenderHH	Gender Household Head		Male, Female
H_MajorChall	Major Challenges		Finances, Health, Crime, Education, Sanitation, Disability, Childcare, Maintenance, Community, Connectivity, None
H_MajorIncSou_Bursary	Major Source of Income	Bursary	
H_MajorIncSou_Grant	Major Source of Income	Grant	
H_MajorIncSou_Income	Major Source of Income	Income	
H_MajorIncSou_Pension	Major Source of Income	Pension	
H_MajorIncSou_Remitt	Major Source of Income	Remittances	
H_MunicServ	Municipal Services		Yes, No, N/A

Code	Description	Details (when binary)	Details (when categorical)
H_MunicServRel	Municipal Services Reliability		Yes, No, N/A
H_NatureDepend	Use of Local Natural Environment		Water, Energy, Food, Combination, N/A
H_NoHH	Number of Household Members		Single, 2-4p, 5-7p, 8-10p, >10p
H_NoHHContri	Number of Household Members who Contribute Financially		0, 1, 2, 3, 4, 5
W_DrinkWaterSouDist	Distance to Main Water Source		Inside, Outside
W_GovtServDelWater	Impact of Government Service Delivery on Water Security		Yes, No, N/A
W_LocalEnvIssuesWater	Impact of Local Environmental Issues on Water Security		Yes, No, N/A
W_MajorDrinkWatSou	Main Source Drinking Water		Tap In, Tap Out, Tap Main House, Rain Tank, Tap In and Bought Water, Multiple
W_OtherWaterSou	Main Water Source – household use		Tap, Both, N/A
W_ToilFac	Toilet Facility		Own Flush, Communal Flush, Other Type
W_WaterAccess	Access to Water		Same, Declined, Improved, N/A
W_WaterAfford	Affordability of Water		Same, Declined, Improved, N/A
W_WaterDemMet	Water Demands Met		Yes, No, N/A
W_WaterQual	Quality of Water		Same, Declined, Improved, N/A
W_WaterState	State of Drinking Water: safe to drink?		Yes, No
E_En_NatGrid	Connected to National Grid		Yes, No
E_EnergyAccess	Access to energy		Same, Declined, Improved
E_EnergyAfford	Affordability of energy		Same, Declined, Improved
E_EnergyDemMet	Meeting energy demands		Yes, No, N/A
E_EnSou_All_Candl	Energy Sources	Candle	
E_EnSou_All_Elec	Energy Sources	Electricity	
E_EnSou_All_Gas	Energy Sources	Gas	
E_EnSou_All_Man	Energy Sources	Manure	
E_EnSou_All_Paraf	Energy Sources	Paraffin	
E_EnSou_All_Wood	Energy Sources	Firewood	
E_EnSou_Cooking_All	Energy Sources used for Cooking		Electricity, Candle, Gas, Manure, Paraffin, Firewood; or Electricity, Other
F_Fishing	Fishing for Food		Yes, No, N/A

Code	Description	Details (when binary)	Details (when categorical)
F_FoodAfford	HH Food Affordability Over Years		Same, Declined, Improved
F_FoodAid	Receive Food Aid		
F_FoodDivers	HH Food Basket Diversity Over Years		Same, Declined, Improved
F_FoodExpend	Proportion of Income Spent on Food		% or category: <25%, <50%, <75%, <100%
F_FoodLoca_Formal	Where Food From	Formal	
F_FoodLoca_Informal	Where Food From	Informal	
F_FoodLoca_OwnGarden	Where Food From	Own Garden	
F_Foraging	Foraging Wild Fruit and Veg for Food		Yes, No, N/A
F_GrowFood	Grown Own Veg or Fruit for Food Needs		Yes, No

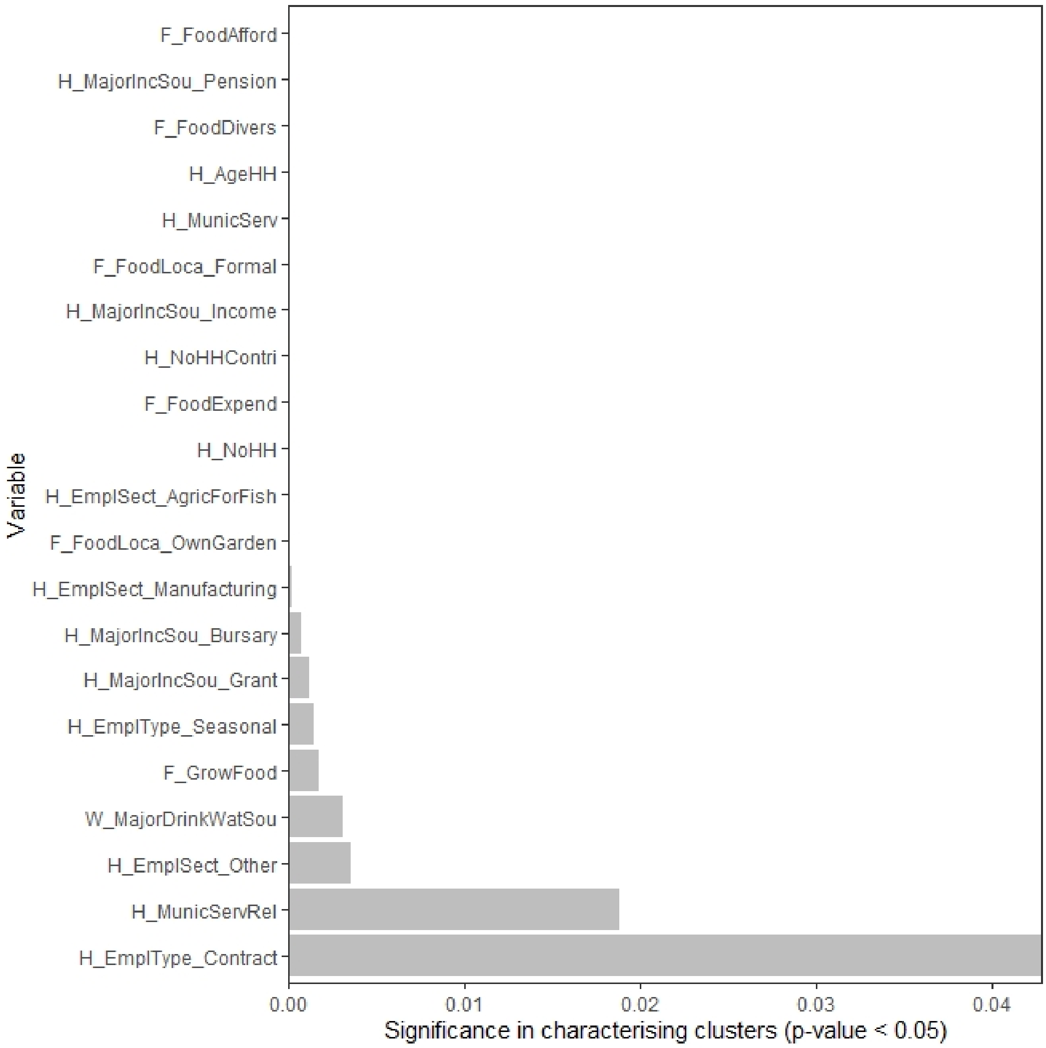


Figure 73 Significance of the significant variables (only variables for which $p<0.05$ are shown) in explaining the clustering of households (for all clusters overall) from three communities in the Berg Catchment: Pniel (50 households), Lanquedoc (63 households) and Noordhoek (92 households) and one community in the uMngeni catchment: Sobantu (50 households). Out of 19 variables (32 columns), 11 were found to be non-significant, and were subsequently removed from the analysis, the other 21 are shown here. H= variables relate to the household, E= variables relate to energy, W= variables relate to water, F = variables relate to food. For the full names of the variables, please refer to Table 32.

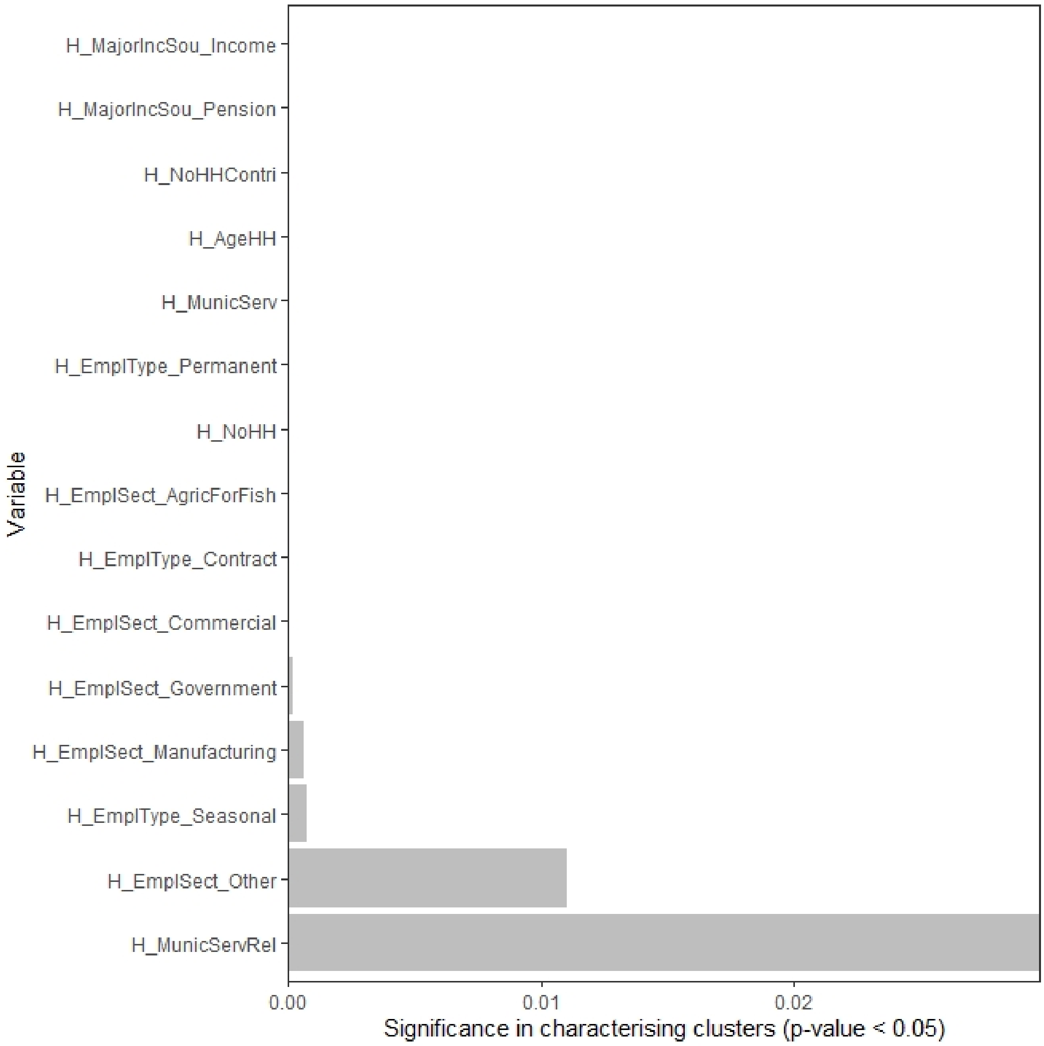


Figure 74 Significance of the significant variables (only variables for which p<0.05 are shown) in explaining the clustering of households (for all clusters overall) from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (92 households), and one community in the uMngeni catchment: Sobantu (50 households), relating to household level contextual information. Out of 10 variables (21 columns), 6 were found to be non-significant, and were subsequently removed from the analysis, the other 15 are shown here. H= variables relating to the household. For the full names of the variables, please refer to Table 32.

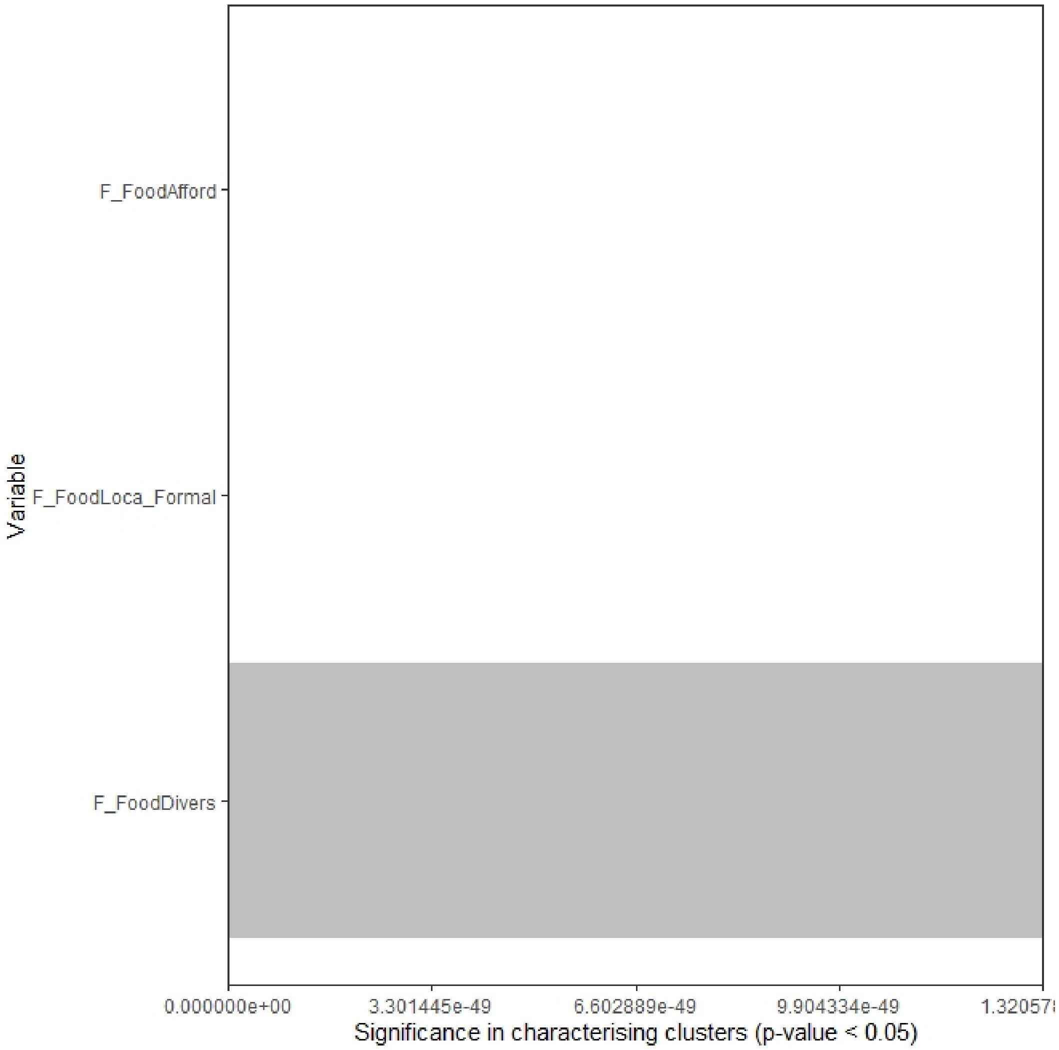


Figure 75 Significance of the significant variables (only variables for which p<0.05 are shown) in explaining the clustering of households (for all clusters overall) from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (92 households), and one community in the uMngeni catchment: Sobantu (50 households), relating to water and food information. Out of 9 variables (11 columns), 8 were found to be non-significant, and were subsequently removed from the analysis, the other 3 are shown here. F = variables relating to food. For the full names of the variables, please refer to Table 32.

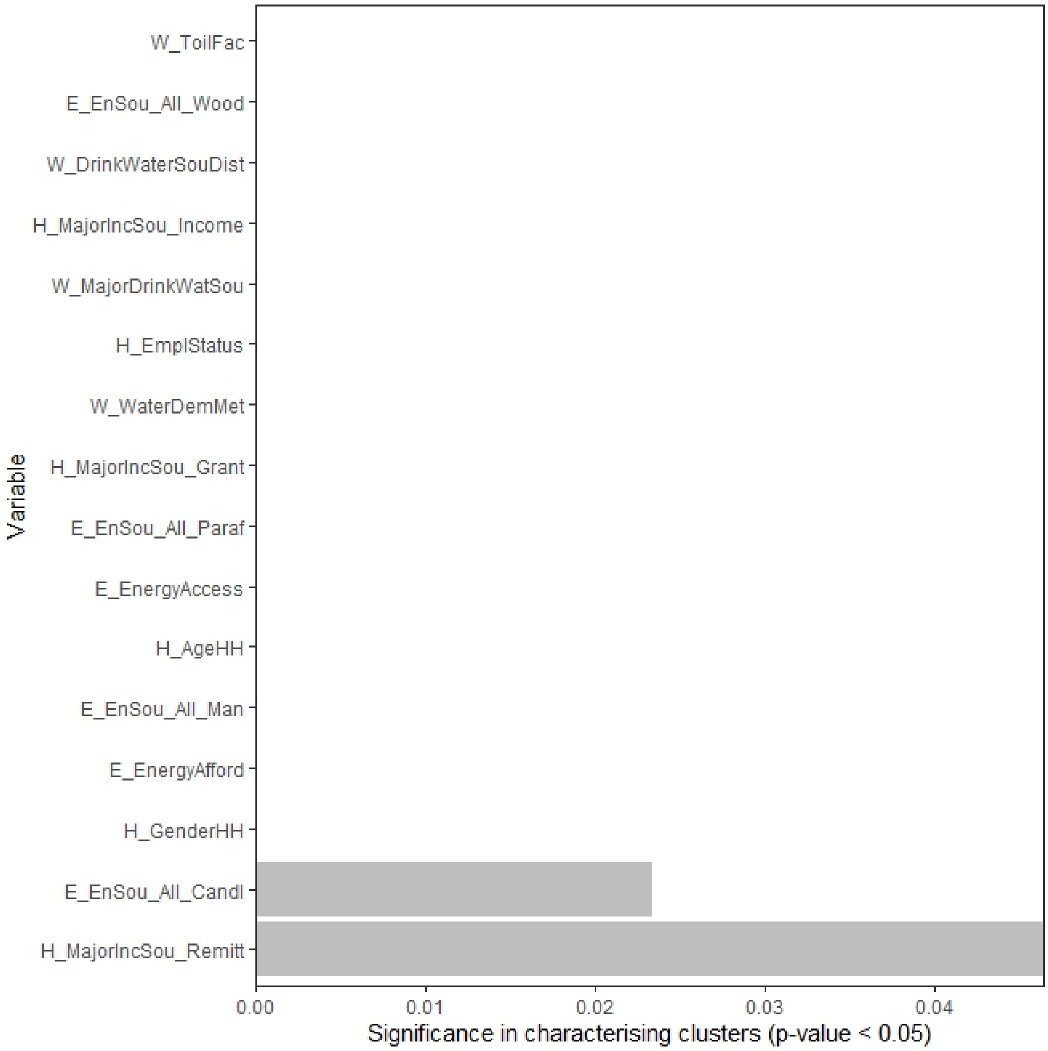


Figure 76 Significance of the significant variables (only variables for which p<0.05 are shown) in explaining the clustering of households (for both clusters overall) from three communities in the Berg Catchment: Pniel (50 households), Lanquedoc (63 households) and Noordhoek (92 households), and two communities in the Keiskamma catchment: Hamburg (142 households) and Melani (141 households). Out of 14 variables (21 columns), 5 were found to be non-significant, and were subsequently removed from the analysis, the other 16 are shown here. H= variables relate to the household, E= variables relate to energy, W= variables relate to water, F = variables relate to food. For the full names of the variables, please refer to Table 32.

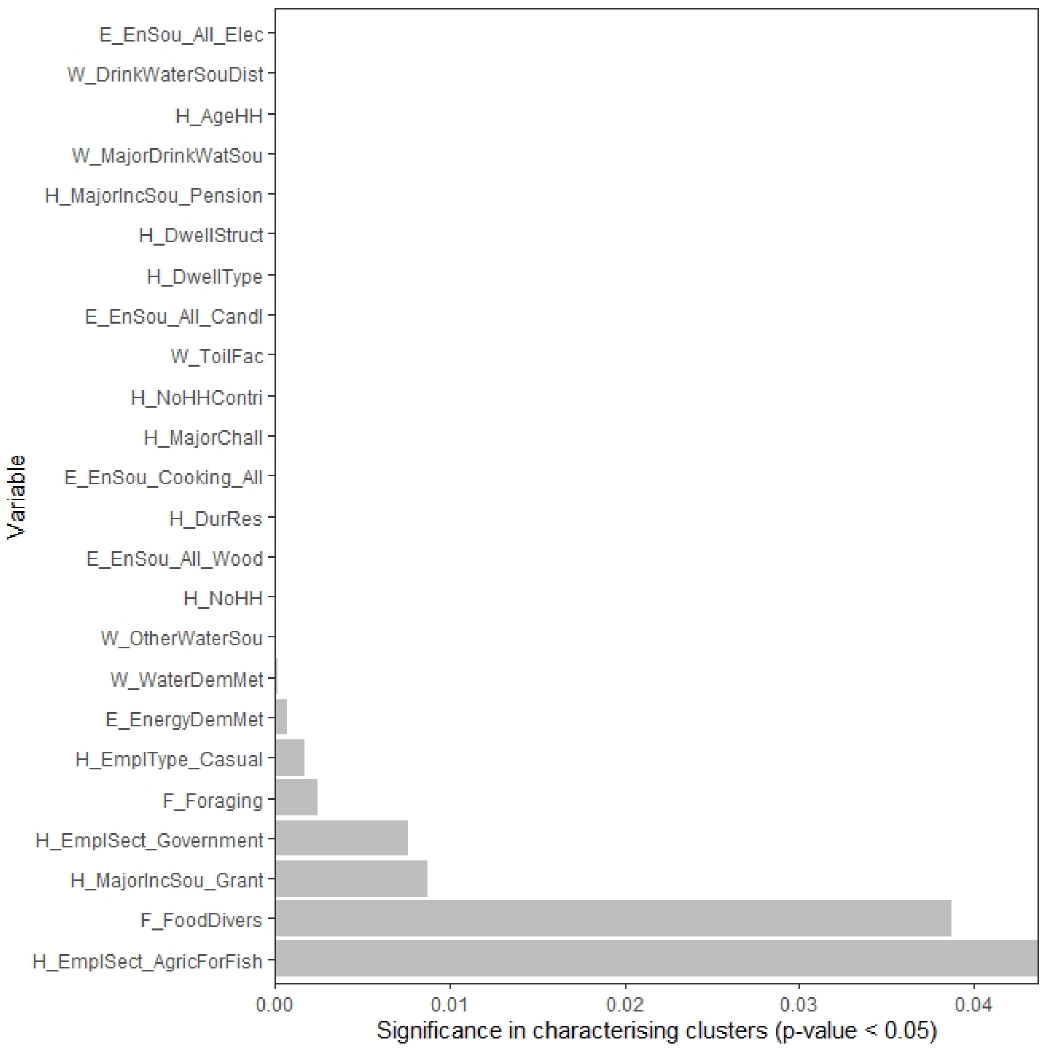


Figure 77 Significance of the significant variables (only variables for which p<0.05 are shown) in explaining the clustering of households (for all clusters overall) from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households). Out of 36 variables (51 columns), 27 were found to be non-significant, and were subsequently removed from the analysis, the other 24 are shown here. H= variables relating to the household, E= variables relating to energy, W= variables relating to water, F = variables relating to food. For the full names of the variables, please refer to Table 32.

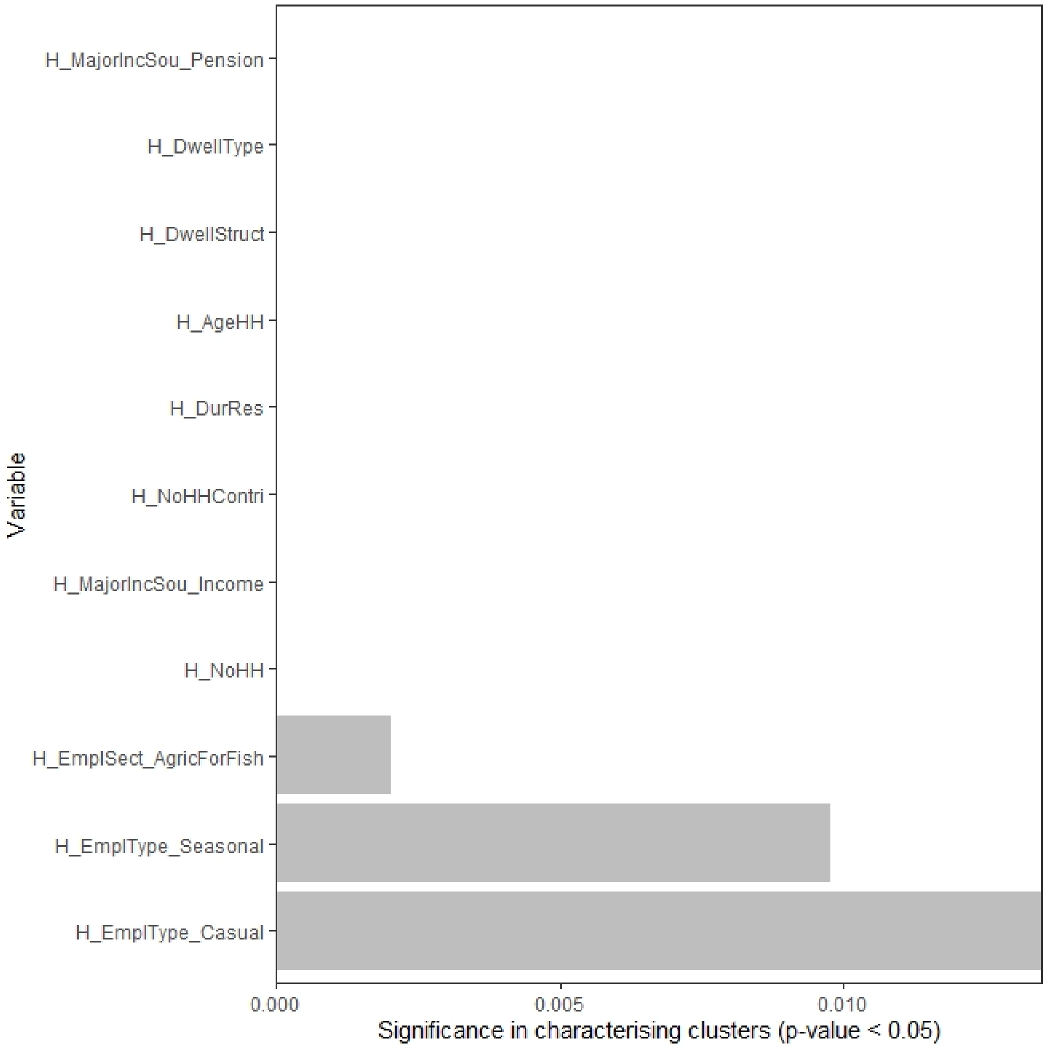


Figure 78 Significance of the significant variables (only variables for which p<0.05 are shown) in explaining the clustering of households (for all clusters overall) from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households). Out of 12 variables (22 columns), 11 were found to be non-significant, and were subsequently removed from the analysis, the other 11 are shown here. H= variables relating to the household. For the full names of the variables, please refer to Table 32.

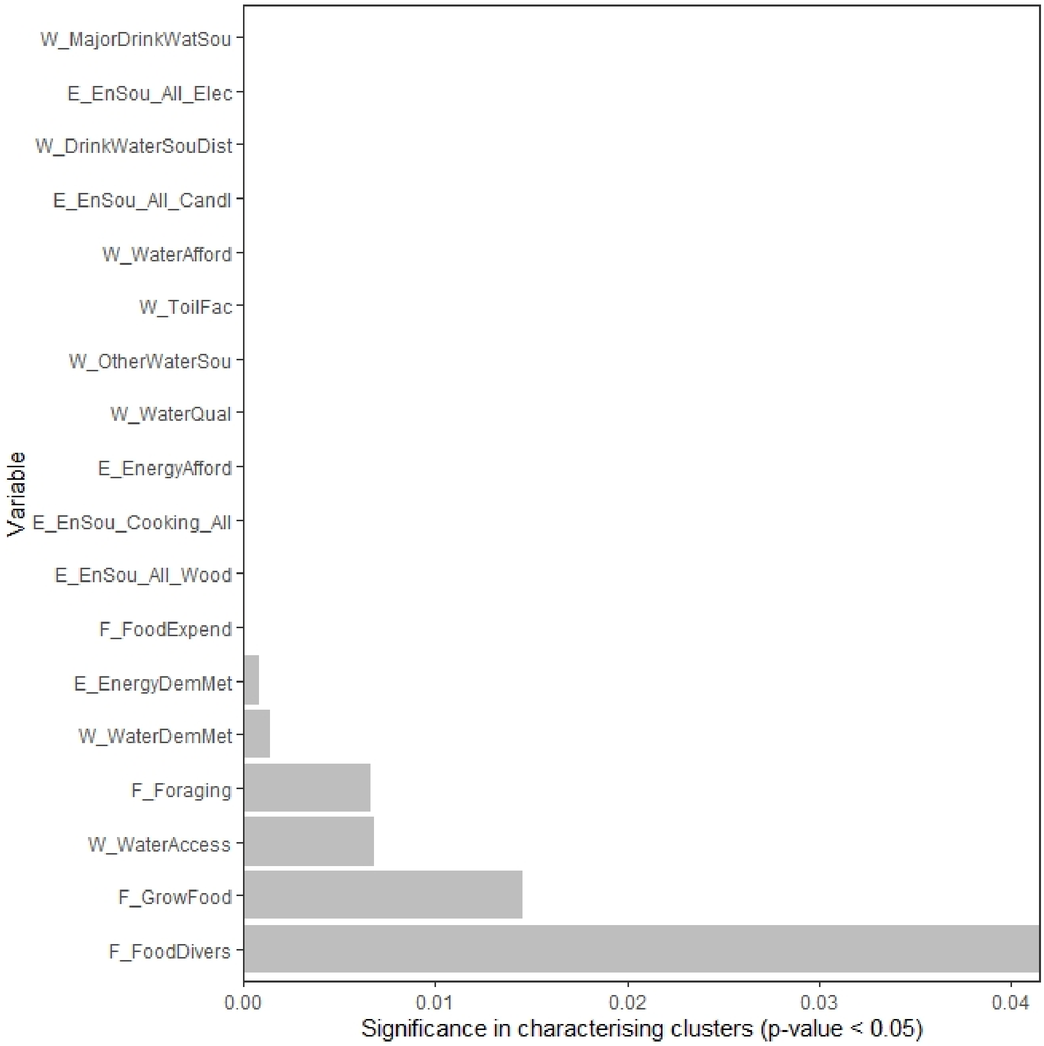


Figure 79 Significance of the significant variables (only variables for which p<0.05 are shown) in explaining the clustering of households (for all clusters overall) from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households). Out of 24 variables (29 columns), 11 were found to be non-significant, and were subsequently removed from the analysis, the other 18 are shown here. E= variables relating to energy, W= variables relating to water, F = variables relating to food. For the full names of the variables, please refer to Table 32.

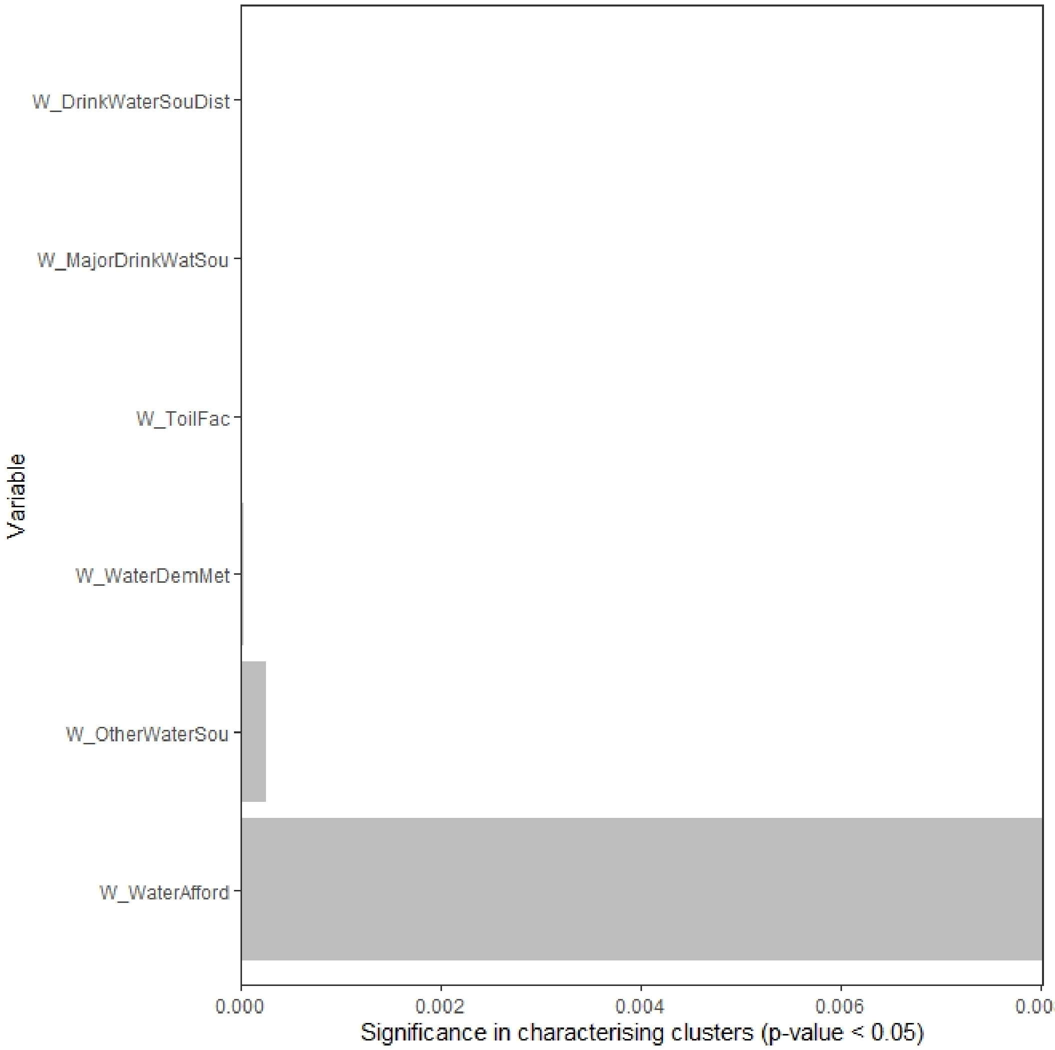


Figure 80 Significance of the significant variables (only variables for which p<0.05 are shown) in explaining the clustering of households (for all clusters overall) from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households). Out of 11 variables (11 columns), 5 were found to be non-significant, and were subsequently removed from the analysis, the other 6 are shown here. W= variables relating to water. For the full names of the variables, please refer to Table 32.

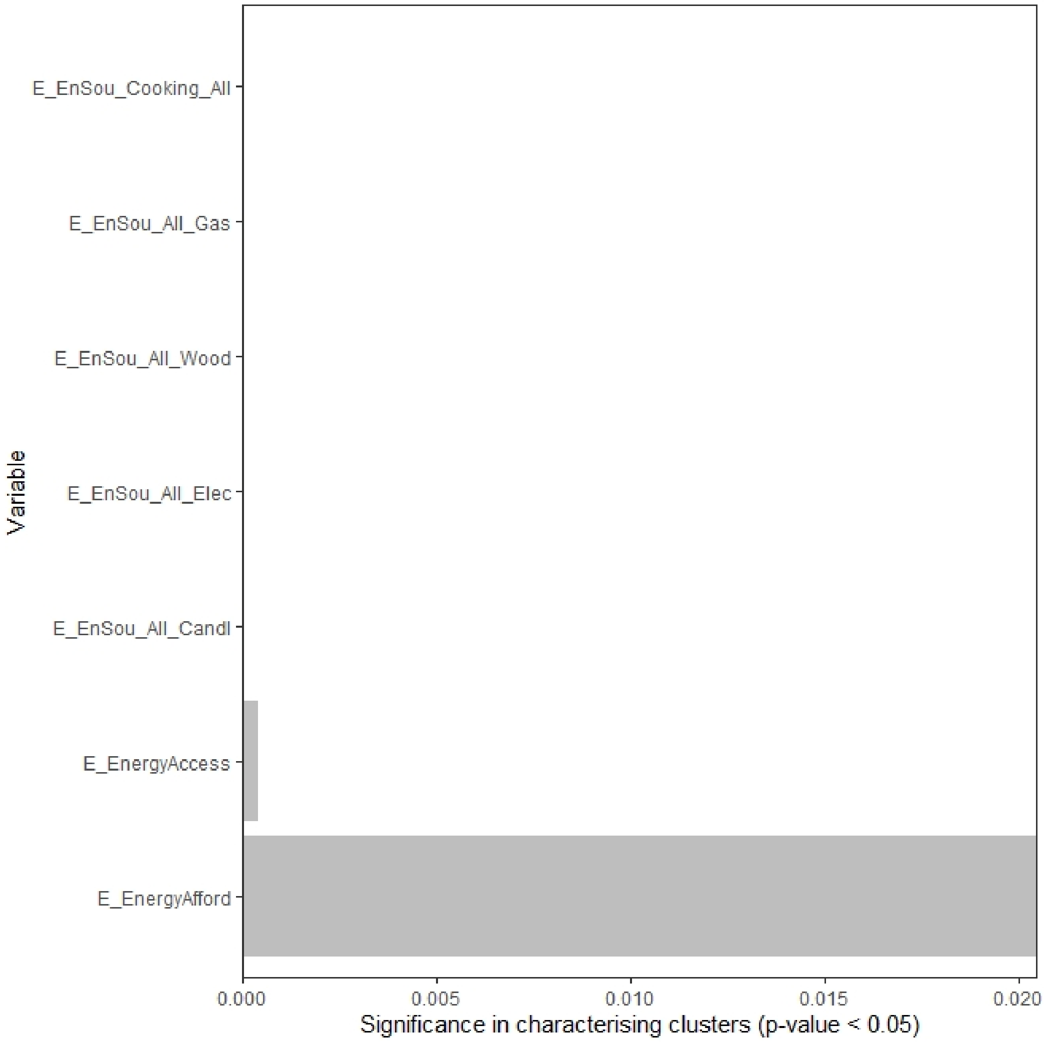


Figure 81 Significance of the significant variables (only variables for which p<0.05 are shown) in explaining the clustering of households (for all clusters overall) from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households). Out of 5 variables (9 columns), 2 were found to be non-significant, and were subsequently removed from the analysis, the other 7 are shown here. E= variables relating to energy. For the full names of the variables, please refer to Table 32.

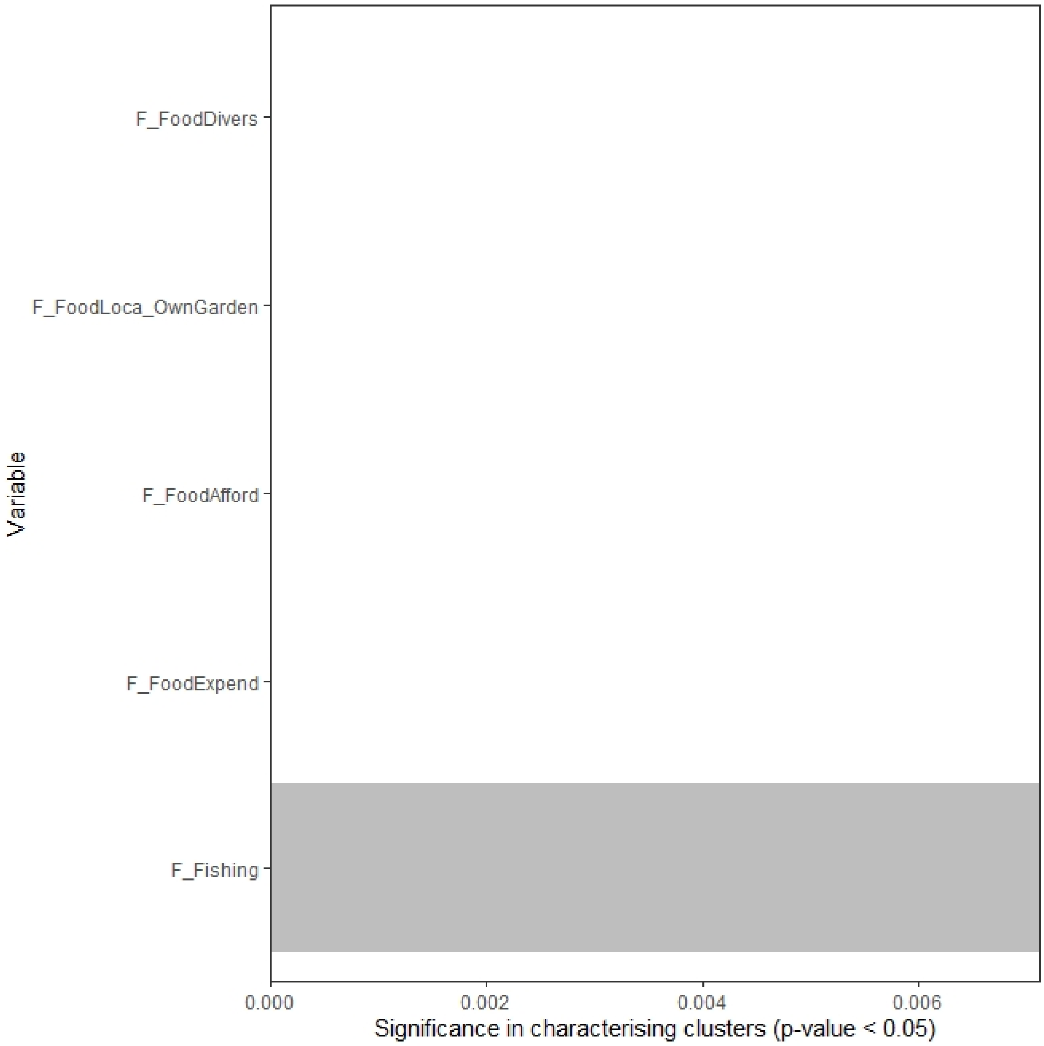


Figure 82 Significance of the significant variables (only variables for which p<0.05 are shown) in explaining the clustering of households (for all clusters overall) from three communities in the Berg Catchment: Pniel (49 households), Lanquedoc (63 households) and Noordhoek (87 households). Out of 8 variables (9 columns), 4 were found to be non-significant, and were subsequently removed from the analysis, the other 5 are shown here. F = variables relating to food. For the full names of the variables, please refer to Table 32.

APPENDIX 4: Focus groups

Pniel/ Lanquedoc: Focus groups focusing on social relations

Potential participants for the three focus groups were identified during the initial administration of the questionnaires in both settlements. The participants were chosen to represent Lanquedoc (both backyard dwellers and main house dwellers) and Pniel. This was done under the assumption that residents living in backyards had different lived experiences to those in the more formal structures. The stratification was maintained in this phase of data collection and analysis as it was believed that it would assist in the identification and comparison of the more vulnerable groups and thus areas. Focus group #1 was conducted with 10 backyard dwellers in Lanquedoc; focus group #2 with 10 main house dwellers that reside in the RDP-like structures within Lanquedoc. Focus group #3 was conducted with 10 main house dwellers in Pniel. Focus groups #1, #2 and #3 were conducted for a duration of 2 hours each. The focus groups were recorded and transcribed in the language spoken by the participants. This was done to maintain the meaning and integrity of the data during analysis as translation from one language to another often obscures meaning. Thus, in Pniel, Afrikaans and English were the preferred language and in Lanquedoc, IsiXhosa and English were preferred. Transcripts were then analysed using Thematic Analysis in the NVivo software where codes and themes were developed (Nowell et al., 2017). The codes were largely guided by the initial questions discussed during the focus group sessions. Following that, because the data was analysed thematically and the original transcripts were in different languages, tree maps were developed to represent the proportion to which each code was in.

The group was required to participate in drawing a map of their neighbourhood, clearly outlining key 'social hotspots'. Social hotspots are areas where community and household social activity is concentrated. This step is related to question 2 below. These could be places where church members gather, or other social gathering locations. The participants were then be required to list the social activities that take place at these locations. A key output that was set to be achieved from this exercise was a map clearly detailing the physical spaces where social relations take place within the community. However, participants were reluctant to participate in this exercise, although they verbally articulated some of the social hotspots. The participants were then required to respond to the questions below regarding social relations.

The focus group discussion was guided by the following questions:

1. What are the biggest challenges that your household/community is facing at the moment?
2. Where do you interact with others in the community? Why?
3. Who do you go to when there is no water and electricity?

(This refers to times when there is no water coming from the taps or electricity in the household for either:

a) Non-payment of accounts or;

b) Faulty infrastructure, e.g. burst pipe or electricity line/transformer)

4. What are the chances that someone goes hungry in the community? What does the community do to assist or support?
    a. IF NOT MENTIONED: Do spaza shops (corner shops) in the area provide goods on credit?
5. Scenario: Let's say there is a flood or fire and an outside donor comes with food and general aid. Who would they contact regarding the distribution of food? Who would you say should get the aid first and why? How should the aid be distributed?

[This question is to assess the presence of authority ranking and whether there is a social hierarchy present within the community]

Sobantu/ Mpophomeni: Focus groups decisionmakers

Decision-makers Questions:

1. What is the role of the organization you are representing in the catchment; what is your role as an individual?

2. How do you and your organization relate to these three resources and sectors (WEF) respectively?

3. Is resources affordability an issue on your agenda, i.e. affordability of these resources for your organisation as well as providing these to society?

4. How could the WEF be relevant in your decision-making, daily tasks and / or your overall mandate?

Questions (Ethembeni NGO and War-Room):

1. How do you as the war room and, or non-profit organisation relate to the different sectors (food, energy and water sectors)

2. How could the WEF be relevant in your task or your mandate?

3. What is important in your context when looking at the WEF-Nexus, and will this (WEF-Nexus) potentially help with the Service Delivery?

APPENDIX 5: List of experts interviewed

The expert interviews relating to the Velddrif (Noordhoek) site are outlined in Table 33.

Table 33 Expert roles and descriptions – Noordhoek.

Designation	Motivation for interview / Area of expertise
Head: Civil Services, Velddrif, Bergrivier Local Municipality	System relating to water and wastewater municipal service in Velddrif
Manager: Income, Bergrivier Local Municipality	Payment for municipal services (water and electricity); Electricity and water tariffs, including indigent support
Manager: Strategic Services, Bergrivier Local Municipality	Economic development plans; IDP; and other Bergrivier Local Municipality strategies relevant to WEF Nexus
Deputy Mayor, Member Financial Services Committee and Councillor of Velddrif Ward 7, Bergrivier Local Municipality	Socio-economic background and current context, Velddrif.
Town Planner – Western Region, Bergrivier Local Municipality	Spatial planning and land-use management, Velddrif.
Manager: Electrical Services, Bergrivier Local Municipality	Electrical system, Velddrif
Senior Manager: Water, West Coast District Municipality	Regional water supply system pertaining to Velddrif
Environmental Manager: West Coast District Municipality	Berg River estuary management, environmental management relating to drought
Manager: Noordhoek NGO – Soup kitchen and youth centre	Socio-economic context of people of Noordhoek; Vegetable garden for soup kitchen
Manager: Fish processing factory	Employment patterns and figures, water and electricity consumption
Manager: Local retail outlet 1	Employment patterns and figures, water and electricity consumption
Manager: Local retail outlet 2	Employment patterns and figures, water and electricity consumption

The expert interviews relating to the Pniel and Lanquedoc site are outlined in Table 34.

Table 34 Expert roles and descriptions – Pniel and Lanquedoc.

Designation	Motivation for interview / Area of expertise
Director: Engineering Services, Stellenbosch Local Municipality	• To understand and evaluate the water and energy system and availability at this level • To assess WEF resource use in the catchment and in both communities • To understand the governance of the water and energy system at this level
LandCare Manager: Western Cape, Cape Winelands District Program: Sustainable Resource Management	• To understand and evaluate the agriculture system (and food availability – to a certain extent) at this level
Senior Agricultural Economist: Western Cape, Cape Winelands District Program: Macro and Resource Economics	• To understand and evaluate the agriculture system (and food availability – to a certain extent) at this level

APPENDIX 6: MoU developed between Academic Institution and Partner Organisations for the purpose of managing the partnership around youth inclusion in the project

*NOTE: Project specific details have been replaced with generic placeholders in *italics*

Memorandum of Understanding

Between

Academic Institution

And

Partner Organisation (typically NPO)

This Memorandum of Understanding (MOU) sets the terms and understanding between the *Academic Institution* and *Partner Organisation* for collaboration around the project 'Exploring the Evidence of Water-Energy-Food Nexus Linkages to Sustainable Local Livelihoods and Wellbeing in South Africa' in the *project site* area only.

Purpose

The *Academic Institution* project, 'Exploring the Evidence of Water-Energy-Food Nexus Linkages to Sustainable Local Livelihoods and Wellbeing in South Africa', involves exploring the interlinkages between the water, energy and food resources at a household and community level, with particular interest in the impact on livelihoods. The project is taking place in three catchments, namely the Berg River in the Western Cape, the Keiskamma River in the Eastern Cape, and the uMngeni River in KwaZulu-Natal. There are two research sites per catchment, and of particular relevance to this MoU, is the one research site on the *name of river*, namely *project site*. This involves the collection of household and community level data in these areas – a task that will require community research assistants. The *Academic Institution,* in seeking to extend the reach of knowledge transfer, capacity building and skills development through trans-disciplinary projects such as this one, wish to develop a programme around the community research assistants that aims to contribute towards achieving these objectives. This includes the identification of partner organisations who work with unemployed youth in the respective research sites and who share a common goal related to the objectives of capacity building and skills development of unemployed youth in the area. Once this has been established, a programme can be co-designed and implemented to support the *Academic Institution's* community research assistant needs, while contributing to the capacity development and upskilling of local unemployed youth through collaboration with the local partner organisation.

This MoU sets out the respective roles and responsibilities, funding arrangements, and duration for the achievement of the Youth Community Research Assistant programme of the WEF Nexus project outlined above.

Roles and Responsibilities

In terms of **youth recruitment** activities in the *project site* area, the *Academic Institution* will draft 2 advertisements; one for the four youth community research assistants and one for the youth leader which will be chosen from amongst the interns at the *Partner Organisation. Partner Organisation* will give their input, *Academic Institution* will finalise and print, and the *Partner Organisation* will put the advertisements up.

The *Partner Organisation* will provide and keep a box in which applications will be dropped off. The *Partner Organisation* is also responsible for opening the box and scanning the applications for the *Academic Institution* to process. The *Academic Institution* will contact the applicants and invite them for an interview that will be held at the *Partner Organisation*. The interview will be conducted by a panel of *Academic Institution* members and a representative from *Partner organisation*.

The *Academic Institution* will contact the successful candidates and is responsible to draft a contract with them, which they will sign. *Academic Institution* and *Partner Organisation* will have an onboarding session conducted at the *Partner Organisation* which will include going through the contract, rules of the *Partner Organisation*, roles of the *Academic Institution* and *Partner Organisation*, expectations and outputs and implications in event of non-delivery.

In terms of **youth training, capacity building and skills development** activities, the *Academic Institution* is responsible for any transport, accommodation and food for the youth community research assistants during workshops. *Academic Institution* is also responsible for developing and delivering training material. The *Academic Institution* must liaise with the *Partner Organisation* to find a suitable date in the event that the training would be held at the *Partner Organisation*.

The *Academic Institution* is responsible for facilitating ongoing knowledge exchanges for the duration of the contract period. *Partner Organisation* will provide input into the knowledge exchange programme where synergies exist with *Partner Organisation's* training programme. The *Partner Organisation* intern will be included in the project as a youth leader to ensure that the knowledge generated during the project is embedded in the *Partner Organisation* and can be further disseminated through the *Partner Organisation*.

In terms of **data collection** activities, an *Academic Institution* student will be responsible for data collection in the *project site* area. This student will work with the youth in managing the running of the questionnaire. The student will also liaise with *Partner Organisation* regarding the possible use of the *Partner Organisation* as their base during data collection. The assigned *Academic Institution* student will be working with the youth during the time of the audit and be responsible for managing the audit and collection of the data.

The focus groups will form part of the data collection and will be identified as the data collection progresses. The focus groups will be held at a separate venue (not the *Partner Organisation*); and the *Academic Institution* will be responsible for all the arrangements around the focus groups.

In terms of **use of the *Partner Organisation*,** the youth may only use the *Partner Organisation* by arrangement with *Partner Organisation* only. This may include the use of computers for data analysis if deemed appropriate.

In terms of **management of the youth**, the *Academic Institution* will be responsible for the management of the youth. The *Partner Organisation* will provide management support when an *Academic Institution* representative or student is not present. This support will include: liaising with the youth if required, communicating with *Academic Institution* if there are any problems and providing any mentorship to the youth that may be required and available.

Funding (Logistical Arrangements)

There are no costs associated with this MoU, besides those relating to the research activities of the *Academic Institution*, which will be covered directly by the *Academic Institution*. Any costs that *Partner Organisation* may anticipate incurring due to the implementation of this MoU are to be dealt with on a case by case basis and approved in writing by the Project Lead *(project leader name)* before being undertaken. Once written approval has been obtained, these costs will be reimbursed or covered up front if possible due to *Academic Institution* administration constraints.

Academic Institution will manage the disbursement of any funds relating to the project activities. This will include a cash incentive for the youth involved in the project. This cash incentive will be related to deliverables, such as data collection, training completion, learning related activity sheet completion, knowledge exchange related tasks and attendance, etc.

Duration

This MOU will remain in place for the duration of the project's Work Package 3 – estimated to take six months from start date[20], and will be subject to amendments or extensions to the overall project agreement. This MOU is at-will and may be modified by mutual consent of authorized officials from both *Academic Institution* and *Partner Organisation*. This MOU shall become effective upon signature by the authorized officials from *Academic Institution* and *Partner Organisation* and will remain in effect until modified or terminated by any one of the partners by mutual consent. In the absence of mutual agreement by the authorized officials from the *Academic Institution* or *Partner Organisation* the MoU will terminate at the finalization of the project's Work Package 3.

Contact Information

Partner name: *Academic Institution*

Partner representative 1: *Project leader*

Position: *Principle Investigator and Project Lead*

Partner representative 2: *Youth coordinator*

Position: Project Work Package 3 Lead

Address: *Academic Institution's address*

Telephone:

E-mail:

Partner name: *Partner Organisation*

Partner representative 1: *Partner Organisation representative's name*

Position:

Partner representative 2: *Partner Organisation representative's name*

Position:

Address: *Partner Organisation's address*

Telephone:

E-mail:

[20] Start date is the date upon which the youth contracts commence

APPENDIX 7: Advertisement used to recruit youth as project community research assistants

*NOTE: Project specific details have been replaced with generic placeholders in *italics*

ACDI African Climate & Development Initiative

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

CALL FOR YOUTH RESEARCH ASSISTANTS

Are you an enthusiastic, self-motivated youngster who is keen to develop life skills?

If yes, this is the right opportunity for you.

About the Project

The African Climate and Development Initiative at the University of Cape Town is conducting a research project funded by the National Water Research Commission in the *Project Site* area that examines the interplay between water, energy and food (WEF Nexus) resources at a household level. The aim of the project is to establish how this nexus impacts on livelihoods and wellbeing at both a household and community level.

This project is working in 3 catchments across the country, the *name of river* being one of these. In the *name of catchment*, the project is operating in 2 sites, namely *project site 1*, as well as *project site 2*. The data collection for the study involves questionnaires, household audits and focus groups. This will be done over a 6-month period, commencing at the end of September 2018 to March 2019.

About the Opportunity

Places available: Maximum 6

Applications are invited amongst local unemployed post-matric youth residing in the *Project Site* area. The youth component lasts for 6 months and is not an employment opportunity but does involve free training and an incentive for successful data collection.

The primary responsibility of the community assistants will be to support the researchers in the community during the data collection process. The youth will also be part of a youth development programme.

Please note that this is not an employment opportunity, nor does it offer employment on completion.

Your Profile

- Youth (18-28 years old)
- Unemployed and residing in Pniel or Lanquedoc
- Matric (Grade 12) or post-matric qualification
- Responsible, organised and of sober habits
- An interest in Sustainable Development in relation to your community and area
- Ability and willingness to engage with the community
- Willingness and keenness to learn
- Possession of a smart phone would be advantageous

Your Tasks

- Conduct household questionnaires in your area of residence (either Pniel or Lanquedoc)
- Conduct and monitor household audits
- Attend training sessions and workshops

Application Procedure

Applications should consist of:

1) a curriculum vitae (CV),
2) a copy of your matric certificate and ID
3) the names and contact details of two referees who are not related to you

Please submit the documents to ***Partner Organisation. Representative's. name*** @ the ***Partner Organisation's premises*** by ***closing date and time.*** Interviews to be held on ***date***. Please note that only shortlisted candidates will be contacted. Should you not be contacted by date, consider your application unsuccessful.

Please address any queries to ***Project Youth Coordinator*** *(ph)* or ***Project site student*** *(ph)*

APPENDIX 8: Interview questions for youth during recruitment

<u>WRC WEF Nexus Project, UCT</u>

Name of interviewer: …………………………… ……………………………………………………………	Signature: ………………………………………………
Research site: ………………………………………….	Date: ……………………………………….

No.	<u>**Questions**</u>	**Candidate 1**	**Candidate 2**
	-		
1	Tell us a bit about yourself?		
2	How long have you lived in *research site*?		
3	What languages are you fluent in?		
4	What do you like about *research site*?		
5	Are you involved in any community-related activities?		
6	Have you done any data collection or surveys before?		
7	Do you think there is a link between food and water?		
8	Do you think there is a link between water and energy?		
9	Would you describe yourself as shy?		
10	What would you describe as your top 2 strengths?		

11	Scenario: You are conducting a household survey. You knock on a door and an old person answers. They appear not to understand you when you introduce yourself and your purpose. What will you do next?		
12	If you won the Lotto, where would you choose to live?		

APPENDIX 9: Attendance at youth training and community engagement events

Community information events pre-study

Pniel/Lanquedoc community leaders and key stakeholders event, 26 July 2018:

ACDI/ UCT INFORMATION SESSION: WATER ENERGY FOOD NEXUS PROJECT
Date: Thursday 26th July
Time: 10 a.m.
Venue: The Dwars River Valley Community Trust Office, Lanquedoc Road.

Name & Surname	Organization	Phone	Email	Signature
Mike Fraser	DRV Community Trust	0835187057	michaelfraser@gmail.com	M. Fraser
Bernie Lakey	Rhodes Food Group	0832705506	bernadette.lakey@rfg.com	[illegible]
Glen Brittin	"	0798999909	glen.brittin@RFG.com	[illegible]
Leon Klate	Pniel Congregational Church	0823725155	pnielchurch@telkomsa.net	[illegible]
Malcolm Johnson	Ward Cllr	0839822351	Malcolm.Johnson@stellenbosch.gov.za	[illegible]
Melissa Simpson	Ward Admin	0615820525		[illegible]
Wenzile Mbanjwa	Living Lands	0826334769	wenzile@livinglands.co.za	[illegible]
Wilmien Wicomb	Boschendal	0789208366	wilmien@boschendal.co.za	[illegible]
Kelly November	Dwars River Valley Community Dev. Trust	0769102477	kelly.november@yahoo.com	[illegible]
Bennie Diederiks	Result	0824527263	bennie@result.co.za	B.D.

Train the Trainer Events

Train the Trainers Workshop #1, 12-13 September 2018:

WEF Nexus Training of the Trainers Workshop: Attendance Register
12 – 13 September 2018
Hlanganani Junction: UCT Main Library

Name	Email	Tel	Day 1 – 12/09/2018	Day 2 – 13/09/2018
1. Vumande Mjanyelwa	MJNVUM001@myuct.ac.za	072348 1873		
2. Penny Price	Pennyleprice@gmail.com	0835713371		
3. Zakiya Abrahams	zakiya.abrahams@gmail.com	0749550118		
4. Wenzile Mbanjwa	wenzile@livinglands.co.za	0825334769		
5. Evelinah Mbekwa	evelinah171@gmail.com	0656406956		
6. Stephen Myburgh	sjohnmyburgh@gmail.com	0604507931		
7. Everyn Wales	everynwales@yahoo.com	0742868935		
8. Nico Pampier	Nicdecox460@gmail.com	066 050 3502		
9. Maxine Brassell	BRSMAX002@myuct.ac.za	0832804838		
10. Setsabile Thwala	Thwsetool@myuct.ac.za	0782885436		
11. Thulani Ningi	Thulaniningi96@gmail.com	0847044123		
12. Martin Chari	mchari@ufh.ac.za	072 802 0386		
13. Ntomboxolo Mbuse	Mandwa32@gmail.com	0737836375		
14. Leo Zhou	Lzhou@uj.ac.za	0827301106		
15. Ntombiyenkosi Nxumalo	Nxumalon1991@gmail.com	0711 267441		
16. Lethu Mahlaba	lethu@duct.org.za	060 573 8039		
17. Ndumiso Mnikathi	ndumie96@gmail.com	078 903 4989		

Community feedback workshops

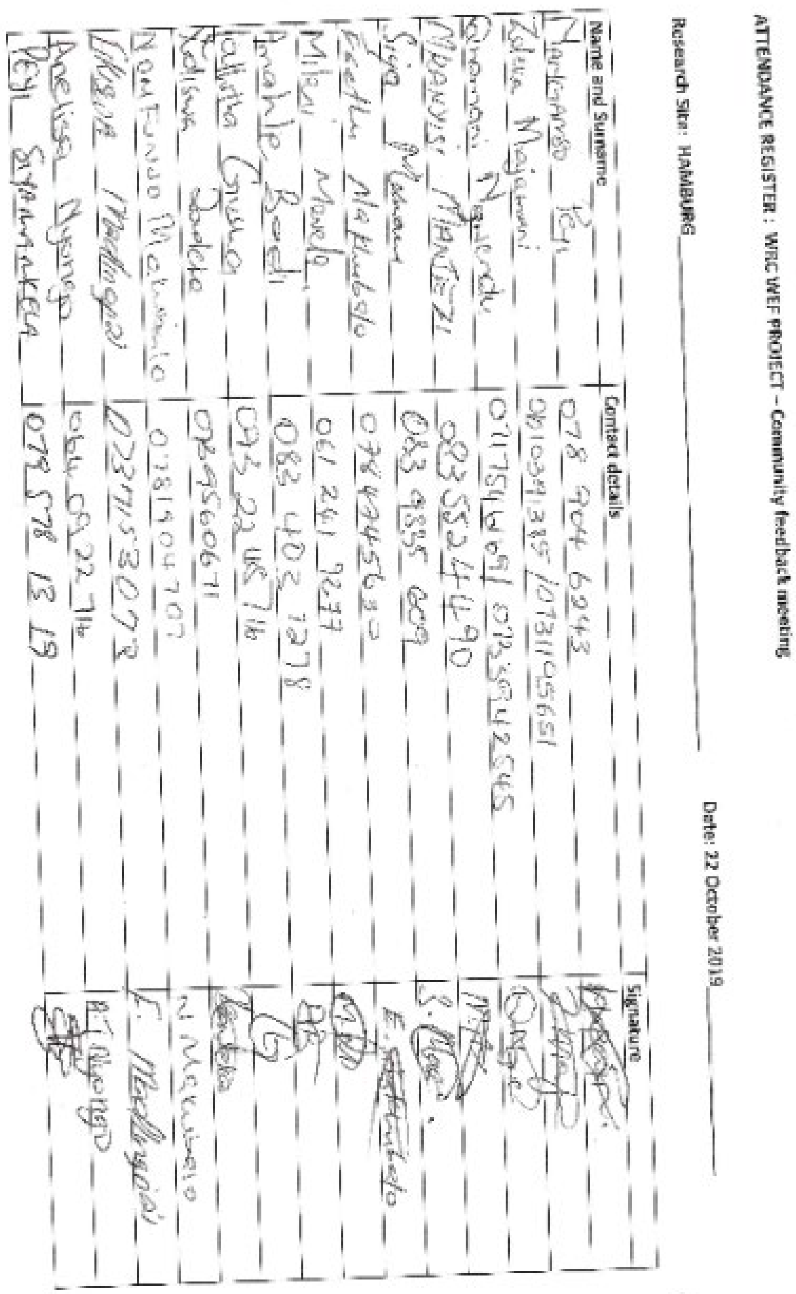
Community Feedback Workshop, Pniel 10 October 2019:

No attendance

Community Feedback Melani, 21 October 2019:

No attendance

Community Feedback Hamburg, 22 October 2019:



ATTENDANCE REGISTER : WRC WEF PROJECT – Community feedback meeting

Research Site: HAMBURG

Date: 22 October 2019

Name and Surname	Contact details	Signature
Nandipho Peyi	078 904 6243	[illegible]
Zolela Majamani	0610391385 / 0731195651	[illegible]
Qhamani Ngwenda	0717546691 / 0733942545	[illegible]
Mbanyisi Mantiezi	0835524490	[illegible]
Siya Mamani	083 9835 609	S. [illegible]
Esethu Makhubalo	0784945630	E. Makhubalo
Mihi Mavela	061 241 9277	[illegible]
Amahle Bandi	083 403 7278	[illegible]
Lathitha Gusha	093 22 45 716	[illegible]
Zolisiwa Zwelo	0839560671	Zwelo
Nomfundo Makwabelo	0781904707	N Makwabelo
Likhona Madlingozi	0737153073	L. Madlingozi
Anelisa Nyongo	064 09 22 716	A.T. Nyongo
Peyi Siyamankela	079 578 13 19	[illegible]

ATTENDANCE REGISTER : WRC WEF PROJECT – Community feedback meeting

Research Site: HAMBURG_______________________ Date: 22 October 2019__________

Name and Surname	Contact details	Signature
Penny Price	0835713371	[signature]
Thulani Ningi	0847044123	
Mbuso	0825419939	

Community Feedback Workshop, Velddrif, 24 October 2019:

BERGRIVIER MUNISIPALITEIT
BERGRIVIER MUNICIPALITY

S CRAFFORD
Onderburgemeester / Deputy Mayor

PO Box 60
PIKETBERG
7320

(022) 913 6000
(022) 913 1390
083 274 0641

craffords@bergmun.org.za

KANTOOR VAN DIE ONDERBURGEMEESTER
OFFICE OF THE DEPUTY MAYOR

20 October 2019

Penny Price
Per e-mail

Good Morning Ms. Price

WATER ENERGY FOOD NEXUS PROJECT – COMMUNITY FEEDBACK SESSION

Community protest action has rocked our otherwise peaceful community of Velddrif, and specifically Noordhoek, all week.

Your community feedback session has been scheduled for 24 October 2019 at the FDSA Youth Centre. I am afraid that the building has been burnt down during the protest action.

We will have to reschedule this meeting at another suitable venue as soon as calm has been restored to the area.

Kind Regards

SM Crafford
Ward Councillor – Ward 7

APPENDIX 10: Training Material from Train the Trainers Workshop 1

NOTE: The training manual consists of 19 presentation slides, copied here for reference only. They were designed as a facilitation and content guide for the Masters students who were trained as trainers and who in turn trained their respective teams of Community Research Assistants.

ACDI African Climate & Development Initiative

WRC WEF NEXUS PROJECT

WATER RESEARCH COMMISSION

TRAINERS MANUAL

2018

Attendance Register

Trainer	Site	
Name	Date	Signature

ACDI African Climate & Development Initiative

Training Objectives

WATER RESEARCH COMMISSION

- Understand more about the project
- Understand more about your role in the project
- Learn about the WEF Nexus
- Learn how to conduct a household questionnaire
- Get to know each other

ACDI African Climate & Development Initiative

Introductory Session 1
Start of session

WATER RESEARCH COMMISSION

- Introduce yourself, your role on the project and the name and basic description of the project.
  - E.g. Hello everyone, my name is Ndu, and I am the Youth Leader in Mpophomeni for this project. The name of this project is the WEF Nexus project, and it looks at **W**ater, **E**nergy and **F**ood and how they impact on households.

Setting the tone

Use this introductory session to set the tone for your training – I.e. think about the level of seriousness, the level of commitment, the level of responsibility and accountability you want to create.

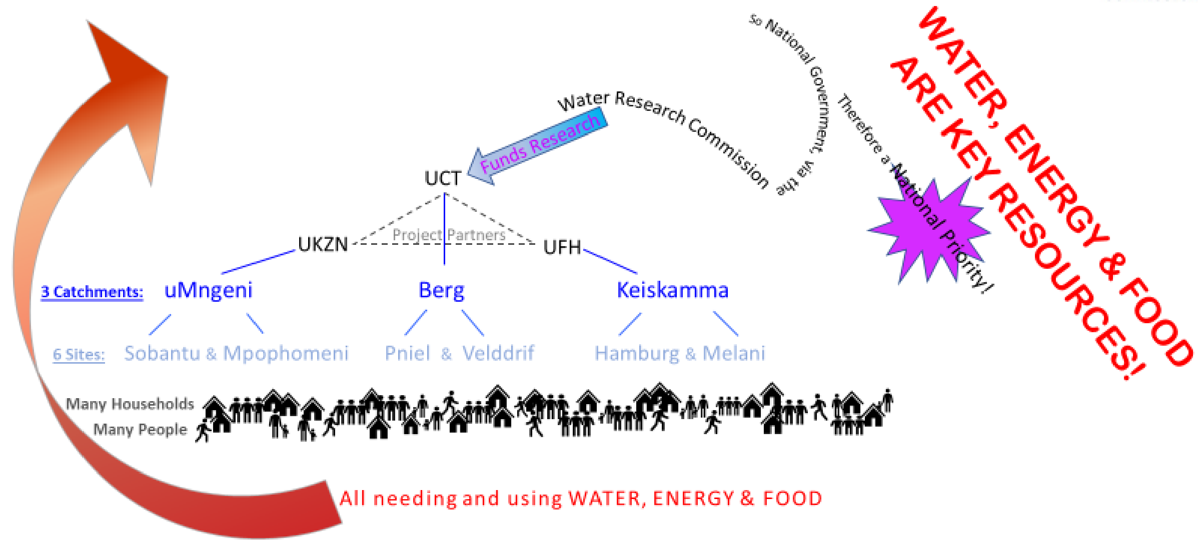
Introductory Session 2
Round of Introductions

There are many ways to use introductions to 'break the ice' and get people feeling a bit more comfortable and less tense. The golden rule is to get people to talk about themselves or give each person a chance to express themselves in some small way. Here are a few examples:

- State who you are, where you are from, and 2 things about yourself, one true and one false
    - Everyone then guesses which one is false. Participants should be encouraged to state something that is believable, i.e. not making it too easy to guess which one is false.
- State who you are, where you are from then tell the group which animal you would be if you were an animal and why.
    - This can be used later in an energiser break, where you can ask everyone to enact their animal.
- State who you are, where you are from and one (or two) thing(s) you like about the place where you live, and why.
    - This can be useful in situations where you are doing transformative work – as it focusses on the positive things in people's surroundings, which, if focussed on, can lead to these things being replicated. This can be called 'Appreciative Inquiry'.

> **Appreciative Inquiry** (AI) is a change management approach that focuses on identifying what is working well, analyzing why it is working well and then doing more of it.

Introductory Session 3
Introducing the Project



Key Concepts:
Resources

There are 3 types of Resources:

- **Human Resources**
  - E.g. teacher in school, doctor in hospital, driver of truck, admin clerk at municipality, etc.
- **Natural Resources**
  - E.g. water, soil, wind, plants, sunlight, etc.
- **Capital Resources**
  - Things that are made and used to make other things, E.g. tools, machines, equipment, etc.

Renewable

Non-Renewable

Session 2
Introduction to the WEF Nexus

Resources Activity – Part 1

Step 1: Instructions to participants

Working in pairs or groups (need 4 pairs / groups) draw up a list (on paper provided) of what you would need for the following activities:

- Cook rice
- Wash clothes
- Grow mielies
- Braai food

Option: You can allocate one activity / group, or ask all groups to do all activities

Step 2: Report back

- Ask each pair / group to take turns in reporting back what they would need for one activity. Choose a different activity per group.
- If they have listed them on post-its, ask them to stick them up on the quadrant provided (you can draw this on a flip chart or can create it with string on a table or anything like that - get creative)
- As they are reporting back, ask them to explain where they get everything.
  - For example when cooking rice, they will mention a pot. Ask them where they get the pot from. When they reply "the cupboard", ask them where it came from before it was in their house's cupboard. When they reply "the shop", ask them where the shop got it from, etc.
  - Do this for as many things as possible without breaking the flow of their report-back too much. Try and stick to about 2 things per group regarding the 'where did it come from' questions.

Once everyone has finished have a discussion on resources: What are they, where do they come from? What does it take to get them to us to use? And start to tie in the water, energy and food where this is obvious.

Session 2
Introduction to the WEF Nexus

Resources Activity – Part 2

Now that you have all the 'stuff' needed to do the activities listed in Part 1, Step 1 in the quadrants, ask the group to identify water, energy and food in the lists.

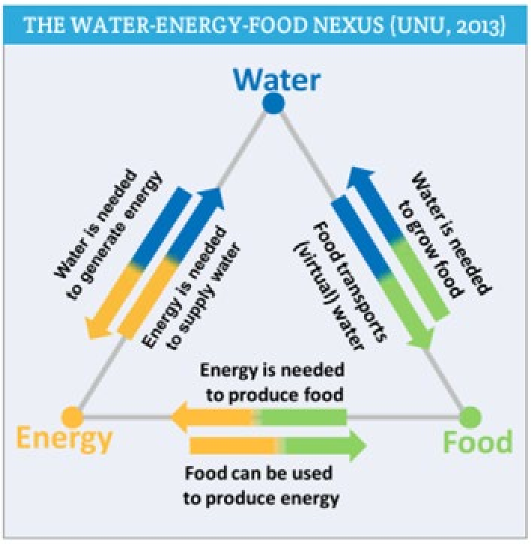
If the lists are on post-its or moveable paper, cluster them together.

Cook rice Rice Pot Water Stove	Wash clothes
Grow mielies	Braai food

Once everyone has finished have a discussion on water, energy and food in the household and how interlinked they are. Explore how you can't cook rice (food) without water or energy; or how you can't wash clothes without water and energy, etc.

P.S. The diagram on the next slide may be useful here

Session 2
Useful Diagram for WEF Nexus Discussion



Session 3
This project – why at a household level?

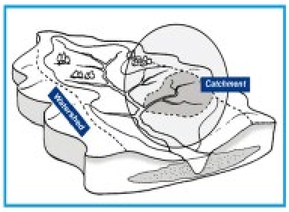
- There is already an understanding of WEF Nexus at the national and regional scales, as well as the catchment scale
- What is NOT well understood is the impact at the household level, AND how this affects livelihoods.
  - This is NB in the SA context where so many struggle with basic service provision, poverty and unemployment

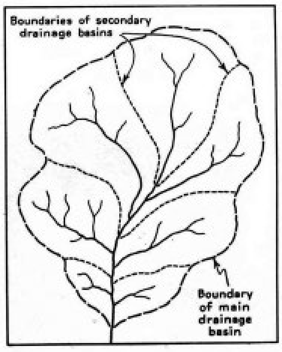
What are Livelihoods?
A livelihood is a means of making a living.
It includes people's capabilities, assets, income and activities required for a means of living.

- People live alone or together in households, therefore a household reflects the smallest unit of collection of people.

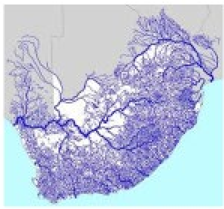
- If we want to get a better understanding of how or if the WEF Nexus is impacting on people, the best way to do this is to find out what is happening at a household level with regards to these resources and explore any impact this has on livelihoods.

Key Concepts:
Catchments





Each stream, no matter how small, has its own drainage basin, the area from which the stream and its tributaries receive water. This basin displays a pattern reminiscent of a tree leaf and its veins.



Session 4
Conducting a Questionnaire

ACTIVITY

Introduce each one of the following elements – one by one – taking time to discuss each one with the group in order to get some insight into local conditions. Introduce role play by inviting each group member to 'play act' an example of what is being discussed.

- Setting out for the day – how do you dress?
  - Comfy shoes for walking
  - Clean and presentable
  - Branded clothing can be misleading (e.g. Dept of Social Development T-shirt could give the impression you are from there)
  - No hoodies over head – need to show face
  - Be mindful of 'revealing' clothes
- What should you take with you?
  - Water and food
  - Charged phone
  - Clip board and back up pens
  - Enough copies of questionnaire

Session 4
Conducting a Questionnaire

- Approaching the house – what to do and what not to do
  - If the gate is closed, make sure you close it behind you when you enter
  - If there is no door bell, shout in a non-threatening & polite manner
  - What do you do if:
    - There is a scary dog in the yard
    - It appears that the residents are drinking heavily or using drugs and you don't want to go in
    - There is shouting coming from inside the house that makes you nervous
- Introducing yourself and the project – **NB** to practice this with some play acting
- Interviewing the 'right' member of the household
  - Go through 'head of household' concept with your team. Make sure they know what you are needing so that they can navigate this space optimally.
- Asking for people's time
  - Be respectful of people's constraints. Be prepared to do the interview in sections and go back to finish it.

Session 4
Conducting a Questionnaire

SAFETY What to do in the event of …. ?

Make sure you have contact details of a family member or similar for your whole team.

Make sure your team has all the relevant emergency numbers on their phones.

ACTIVITY

Ask the team to work in pairs and see if they have phone numbers for the following:

- Their own doctor
- Nearest hospital
- Ambulance
- Other emergency medical responders
- Police
- Traffic Police
- Fire Station

Session 5
The Questionnaire – getting started

Covers Questionnaire Section A – General Information

- Explain the importance of the general information to the team
- Go through each entry and explain why it is there
- Get the team to practice asking one another these questions

Session 5
Water – Getting the interview flowing

Covers Questionnaire Section B – Water

- Explain the importance of the general information to the team
- Go through each entry and explain why it is there
- Get the team to practice asking one another these questions

Session 6
Keeping the energy in the room

Covers Questionnaire Section C – Energy

- Explain the importance of the general information to the team
- Go through each entry and explain why it is there
- Get the team to practice asking one another these questions

Session 7
Food for thought

Covers Questionnaire Section D – Food

- Explain the importance of the general information to the team
- Go through each entry and explain why it is there
- Get the team to practice asking one another these questions

APPENDIX 11: Training Material – Train the Trainers Workshop 2

WRC WEF NEXUS PROJECT – TRAIN THE TRAINERS WORKSHOP 2

Date: 9-11 January 2019

Workshop Manual

WP3 SUGGESTED APPROACH

Safety, data collection and knowledge exchange

Managing the youth: Guidelines for the Project Masters Students

- Set the rules up front. Be clear regarding your expectations – what you want them to do, when and how; what they will be paid and how. Decide on all this before you start. This should include things such as dress code, manners, approach, handwriting, etc.
- Set up communication protocols from the start – e.g. a Whatsapp group, or a group leader who they can check in with who will let you know of any changes, etc.
- Make arrangements and keep them – lead by example.
- Everyone pitches up & on time – if not they must let you know. Have consequences
- Training days you provide catering from your field work budget.
    - I bought rolls and eggs or chicken or cheese and made rolls the night before for everyone; I also bought cooldrink. This was cheap, but labour intensive – so instead of working up my data, I was running 'Penny's Training and Catering'. I hope it also demonstrated my commitment to a low budget project.
- Work days (data collection days) they must bring their own food and water.

- You provide clip boards, pens and pencils – i.e. what they will need to collect the data for you
- Have boundaries and a mechanism to remove someone from the programme if they are compromising your data collection or your team's safety.
    - Remember your data collection, along with your and your team's safety are your priorities.
- If you have a youth leader or similar, decide on their role. This may change as you hit the 'reality on the ground', but then stop and renegotiate around the changes.
- I start the morning with a check in when I am collecting data, so that we can discuss any changes, reflect on the day before if we were collecting data, and plan the day. This way we can address any changes that may be required.

Budget:

- You each have a budget of Rx per site for the youth component. In the Berg catchment we have paid the youth on a weekly basis for work done. We have paid them in cash. This can be a bit risky, as you have to carry large sums on you when the week has been a busy one – and it is usually a Friday – which has its own 'nature'. Think about how you are going to do this.
- So far we have paid the youth Rx per questionnaire – which they have to do in pairs, so they get Rx/2 each.
    - A questionnaire takes about an hour, so Rx becomes an hourly wage and this is double the minimum wage.
- If you have a youth leader or similar decide if there will be any difference in their remuneration. This should only be the case if they carry extra responsibility or tasks. In Velddrif the Youth Leader helped me pre-data collection with scoping out the area and selecting households, etc. I paid him at the hourly rate of Rx/hr for this additional work. If I ask him to do anything additional, I pay him for it and we make this clear when we are making the arrangements.
- I have been completely transparent with the Velddrif group about the finances. I told them up front what the budget is for this component of the work.
    - I then did a projection of the various paid tasks (i.e. data collection) we will be doing and estimated the allocation to each task.
    - Each week I give them a print out of what they have all earned and what our remaining balance is.
    - I have very much of a co-production style, so this works with my style. You might not like this, so think about how you are going to do it. Do a projection regarding how much each data collection task in your area is going to cost – how long, how many sampling points, how many people, etc. and do some planning.

    - You will need to account for all the money spent – so make sure the youth sign receipts for any monies you give them and that you keep those safe.
- You also have a Rx fieldwork budget per site, which is for your transport, accommodation, etc. I.e. your fieldwork costs. What you are allowed to spend this on and if there are any limits per item, so please check in with the Project Leader on this.

AUDIT TRAINING – Guidelines for the Project Masters Students

Purpose:

- Understanding household use of resources, i.e. capturing how and how much energy, water and food resources enter into and exit the household each week.
- Raise awareness of opportunities for savings

Suggested Approach:

- Determine your minimum requirement
    - This depends on your circumstances and budget. Discuss this with Project Leader and your supervisor.
    - You should include the households of the youth in your audit and **at least** one other. So if they can each do their households + 1 other, that would be great. If you have a big team, you could split them up into 3 teams and run the audits over 1 week instead of 3 weeks.

- Suggestion is to sample a minimum of 5 houses for 2 days (1 week day and 1 weekend) for each resource. This will mean:
    - 5 (houses) x 2 (days) x 3 (resources) = 30 data points
    - I paid the youth Rx per household audit sheet per day. Day = 24 hrs.
    - I paid them RX for piloting (not full day) on their own households.
    - So your costs just in terms of paying the youth if that is your minimum is RX x 30

Guidelines Water Audit

The basic premise behind household water audits is to monitor household members' water using activities over a period such as a 24-hour period. As activities can vary quite significantly between weekdays and weekends, it is useful to get a sample of each day. There are 2 approaches we can use:

1. Go with average volume water used per water related activity
2. Measure some of the water related activities in the households and use that data to establish consumption patterns

I suggest where possible go with both. We collect the use data and where possible we validate the exact litres used. That way we will be able to compare using the estimates based on averages, and where possible we will be able to see differences in consumption across the areas where we have been able to verify.

Introduce the youth to the concept of household resource modelling/ auditing. Emphasise the point that by collecting data, they will know how much they are using and that this can be helpful in reducing bills through identifying leaks and changing wasteful patterns of behaviour.

Familiarise yourself with the material below – this includes all the support material

I suggest you print out 2 or 3 sheets per household and ask the youth to stick the pages on the wall in the area where the activity takes place, e.g. stick one close to the ablution space and one close to the cooking and washing space.

These activities will empower not only the youth, but the householders too.

WRC WEF NEXUS PROJECT

HOUSEHOLD RESOURCE USE ASSESSMENT

TRAINING MANUAL and RESOURCE PACK

For this training you will need the following:

Pencils and erasers, clipboards, paper, printed audit sheets, Prestik, 5 litre bucket and 1litre plastic measuring jug

General Introduction to Household Resource Assessment

Activity 1 – Introduction

Standing in a circle give everyone a chance to introduce themselves and say one thing they like about their community and what they expect to get out of this training.

Trainer introduces the project and broad concept of resources – life support Water and Food and the Energy it takes to produce these, etc.

Activity 2 – What do we mean by 'energy'? (25 mins)

In the household and community context, what do we mean by the term 'energy'?

Turn to the person next to you and discuss what the term 'ENERGY' means to you. Focusing on household and community ENERGY use and sources write down 6 key words or phrases on the paper provided. When done come stick them in the space provided.

Trainer sorts papers and facilitates a discussion on energy in the catchment

NOTES:

CAPACITY DEVELOPMENT OUTPUT 1 – Conducting household energy audits

An audit is when you inspect, survey and analyse energy flows in a household with a view to reducing the amount of energy input without negatively impacting the outputs.

Activity 3: Match the terms to the pictures (15 mins)

Inspect	**Survey**	**Analyse**

Trainer facilitates discussion on auditing and the various stages and rationale behind it.
Trainer sums up concept of energy auditing.

BREAK for TEA

Activity 4 – What energy sources do we use in our households? (30 mins)

Divide into 2 groups and complete Activity Sheet 1 (Household Energy Sources) drawing on what you know about your own household's energy sources.

ACTIVITY SHEET 1 – Household Energy Sources: My House

Address of household

Number of people living in household	**Children**	**Youth**	**Women**	**Men**
Cooking 1				
Cooking 2				
Food Prep 1				
Food Prep 2				
Food Prep 3				

Keeping food cold

Heating 1

Heating 2

Water heating 1

Water heating 2

Lighting 1

Lighting 2

Cleaning 1

Cleaning 2

Cleaning 3

Entertainment 1

Entertainment 2

Other 1

Other 2

Other 3

Activity 5 – Conducting a Household Energy Audit – Part 1 (45 minutes)

In this activity, we will work in pairs, but each person must complete their own Activity Sheet 2. This will be done by using what you know about your own household and drawing on information from the two Info Boxes (1&2) included below. The trainer will explain in more detail how to go about completing the Activity Sheet.

ACTIVITY SHEET 2 – Electrical Appliance Energy Usage: My Household

Appliance	**# In Household**	**Watt (W)**	**How long is it on for every time**	**# Times used / day**
EXAMPLE: Kettle	*1*	*2200*	*3 mins*	*8*

INFO BOX 1 – Basics of Measuring Energy

Energy is defined as the capacity to do work. It is measured in units called joules (J).

Power is the rate at which energy is used. This is measured in watts (W).

One watt is equal to the energy consumed at a rate of one joule per second.

However, as energy is used in vast amounts throughout the world, bigger units are normally used:

100 watts (100 W) = one hundred watts

1 kilowatt (1 kW) = 1 000 (one thousand) watts

1 megawatt (1 MW) = 1 000 000 (one million) watts or 1 000 kW

1 gigawatt (1 GW) = 1 000 000 000 watts or 1 000 000 (one million) kW or 1 000 MW

1 terawatt (1 TW) = 1 000 000 000 000 watts or 1 000 GW

An appliance's power use is expressed in watts, for example, a **60 W light bulb**.

To understand the **total amount of energy used**, we need to think about **how long an appliance is used for**, i.e. the amount of energy used in kilowatt-hours (kWh).

For example, if a 60 W bulb is left on for ten hours, it will use 60 x 10 = 600 Whr = 0.6 kWh.

Similarly, a 1 kW heater used for half an hour, it will use 1 x 0.5 = 0.5 kWh.

INFO BOX 2 – Typical home appliance electricity consumption

Appliance	**Power use (watts)**
Cooking	
Kettle	1900
Hotplate (Small)	1275
Hotplate (Large)	2400
Electric Frying Pan	1250
Snackwich	1200
Toaster	1010
Microwave	1230
Electric Stove	3000
Food Processor	166
Lighting	

Incandescent Bulb (40W)	40
Incandescent Bulb (60W)	60
Incandescent Bulb (100W)	100
Compact Fluorescent CFL (12W)	12
Compact Fluorescent CFL (18W)	18
Compact Fluorescent CFL (20W)	20
Security Light (120W)	120
Water Heating	
Geyser (Electric)	2600
Geyser (solar with electric backup)	2600
Refrigeration	
Chest Freezer	105
Fridge with Freezer	158
Fridge (without Freezer)	250
Home Maintenance	
Dishwashing Machine	2500
Vacuum Cleaner	1000
Laundry	
Washing Machine	3000
Tumble Drier	3300
Iron (Steam)	1235
Iron	980
Entertainment / Office	
TV	
Cell Phone Charger	9
Hairdryer	647
Computer	134
Music System	

Break for LUNCH

Activity 6 – Conducting a Household Energy Audit – Part 2 (80 minutes)

This activity takes the auditing process a bit further, so that you can get a picture of how much electricity is used in your household per day or per week. This is going to require a few calculations.

In Activity Sheet 2 you collected data on your household electricity usage. We are now going to use that data to work out the daily consumption in kilowatt hours of your household.

Using the example of the kettle in Activity Sheet 2, you know that:

- The example household has 1 kettle
- It draws 2200 watts
- It is used 8 times a day (on average)
- And takes 3 minutes to boil every time it is used

So how much electricity does it use in a day? This is how we work it out…

- Firstly convert watts to kilowatts (this will make the number smaller and easier to work with)
  - 2200 watts / 1000 = 2.2 kilowatts
- Then multiply the number of times you have used it by the number of minutes you use it for every time (so that you have the total time for the day).
  - 3 minutes x 8 times per day = 24 minutes
- Then convert the minutes into hours (we don't want to work with thousands of minutes to get our consumption for the day!)
  - 24 minutes / 60 = 0.4 hours
- Then multiply the kilowatts by the hours to get kilowatt-hours
  - 2.2 x 0.4 = 0.88kwh

When you buy prepaid electricity, you are buying x units, which is in fact, x number of kilowatt-hours. So, in the example below in Activity Sheet 3, the household uses almost 1 unit per day just for the kettle.

Work in pairs using Activity Sheet 3, calculate the kilowatt-hours for the rest of your table. Ask for help if you get stuck or are confused.

ACTIVITY SHEET 3 – Daily Household Electricity Usage in kWh

Appliance	**Watts**	**Kilowatts**	**Time used per day (minutes)**	**Time used per day (hours)**	**Kilowatt-hours**
		watts/1000	# times used x how long used each time	Minutes taken / 60	Kilowatts x Hours
Kettle	*2200 W*	*2200/1000 = 2,2 kW*	*8 x 3 = 24 minutes*	*24 / 60 = 0,4 hrs*	*2,2 kW x 0,4 hrs = 0,88 kWh*

Break for TEA

Activity 7 – Conducting a Household Energy Audit – Part 3 (30 minutes)

This activity refers to Activity Sheet 1 completed under Activity 4 and looks at the other energy sources used in your household besides electricity. Working out consumption patterns around these can be more difficult as they do not have the same units nor clear energy use stamped onto the appliances, etc. However, we can still get a good idea of the costs involved in activities that use these energy sources.

ACTIVITY SHEET 4 – Cost of Use of Non-electrical Household Energy Sources

Energy Source	**Use**	**Amount used / week**	**Cost / unit**	**Cost / week**
		Units such as litres, kilograms, bunches, bags		Unit cost x # units used / week
Paraffin	*Heating*	*3 litres*	*R5/l*	*R5/l x 3 l = R15*

ACTIVITY 8 – **Homework Activity (10 mins)**

This activity will be done at home. Collect clean Activity Sheets 1, 2, 3 & 4 and fill them out at home, checking all your appliances and confirming other energy source use, how much, and what the costs are.

Trainer asks the group to stand in a circle and using the 'talking ball' every participant and facilitator reflects on the day.

Everyone helps to pack up, followed by closure

END of DAY 1

Household Energy Audit Sheet

Auditor name:				
House address:				
Number of people living in the house				
Dates of Audit:				
	Appliance	**Watts**	**Times used per day**	**How lo**
Examples	*Microwave*	*1230*	*111*	*5 mins,*
	Kettle	*2200 W*	*1 1 1 1 1*	*3 mins*
Personal Care	Hairdryer			
	Hair Iron			
	Other (specify)			
Entertainment	TV			
	Music system			
	Cell phone charger			
	Computer			
	Speaker			
	Other (specify)			

Household Energy Audit Sheet

Cleaning	Washing machine			
	Dish washer			
	Vacuum cleaner			
	Other (specify)			
Food Preparation	Kettle			
	Toaster			
	Snackwich			
	Hot plate			
	Oven			
	Microwave			
	Fridge			
	Chest freezer			
	Other (specify)			
Lighting	Light type 1 (How many?)			
	Light type 2 (How many?)			
	Light type 3 (How many?)			

Household Energy Audit Sheet

Water and space heating and cooling	Geyser			
	Heater			
	Fan			
	Other (specify)			

WATER

Activity 9 – Introduction (20 mins)

Standing in a circle, use the 'talking ball' to give everyone a chance to reflect on their homework, their thoughts on yesterday and what they are looking forward to today. Everyone to mention one thing they learned yesterday.

Activity 10 – Where does your water come from? (10 mins)

In groups of 2 discuss where you think your water comes from. Write these down on the sticky notes provided and stick them on the board when you are finished.

Trainer to cluster the water sources together and use this to inform a discussion about water sources in the area with the group.

CAPACITY DEVELOPMENT OUTPUT 2 – Conducting Household Water Audits

Inspect **Survey** **Analyse**

Trainer to introduce water audits, giving an overview – why and how

Activity 11 – Household Audit – Identifying household water using activities (20 mins)

Work through Activity Sheet 5 and identify the household water uses in your household, estimating the number of times the activity is done in a day as well as the number of people engaged in the activity. There is room to add additional items or comments in the rows below each item.

ACTIVITY SHEET 5 – Estimating Household Water Uses

Activity	# times activity done / day	# People doing the activity in a day
Washing hands and face	3	
Basin wash		
5-minute shower		
Flushing toilet		
Drinking water (cup)		
Washing dishes (hand)		
Dish washing machine		
Washing clothes (hand)		
Washing machine (3 kg load)		
Cooking meal for 5		
Leaking tap (1 drop / second / day)		
Watering garden / plants		
Washing car		

Other

Other

Other

Other

TEA BREAK

Activity 12 – Household Water Audit Part 2 (40 mins)

Using Info Box 3 below, estimate the amount of water used in each activity identified above in Activity Sheet 5.

Activity Sheet 6 – Household water consumption

Activity	Ave litres water used / activity (l)	# times activity done / day	Total water used /person/day (l)	# people in household	Total household water consumption / day (l)
Washing hands and face	1,5	3	1,5 x 3 = 4,5	4	4,5 x 4 = 18

INFO BOX 3 – Typical household water use

Activity	Ave litres water used / activity (l)
Washing hands and face	1,5
Basin wash	4-8
5-minute shower	80-100
Flushing toilet	6-21
Drinking water (cup)	0,25
Washing dishes (hand)	18 single sink, 36 double sink
Dish washing machine	17-45
Washing clothes (hand)	40
Washing machine (3 kg load)	80
Cooking meal for 5	3
Leaking tap (1 drop / second / day)	30-60
Watering garden	
Washing car (with bucket)	6-8

Activity 13 – Homework:

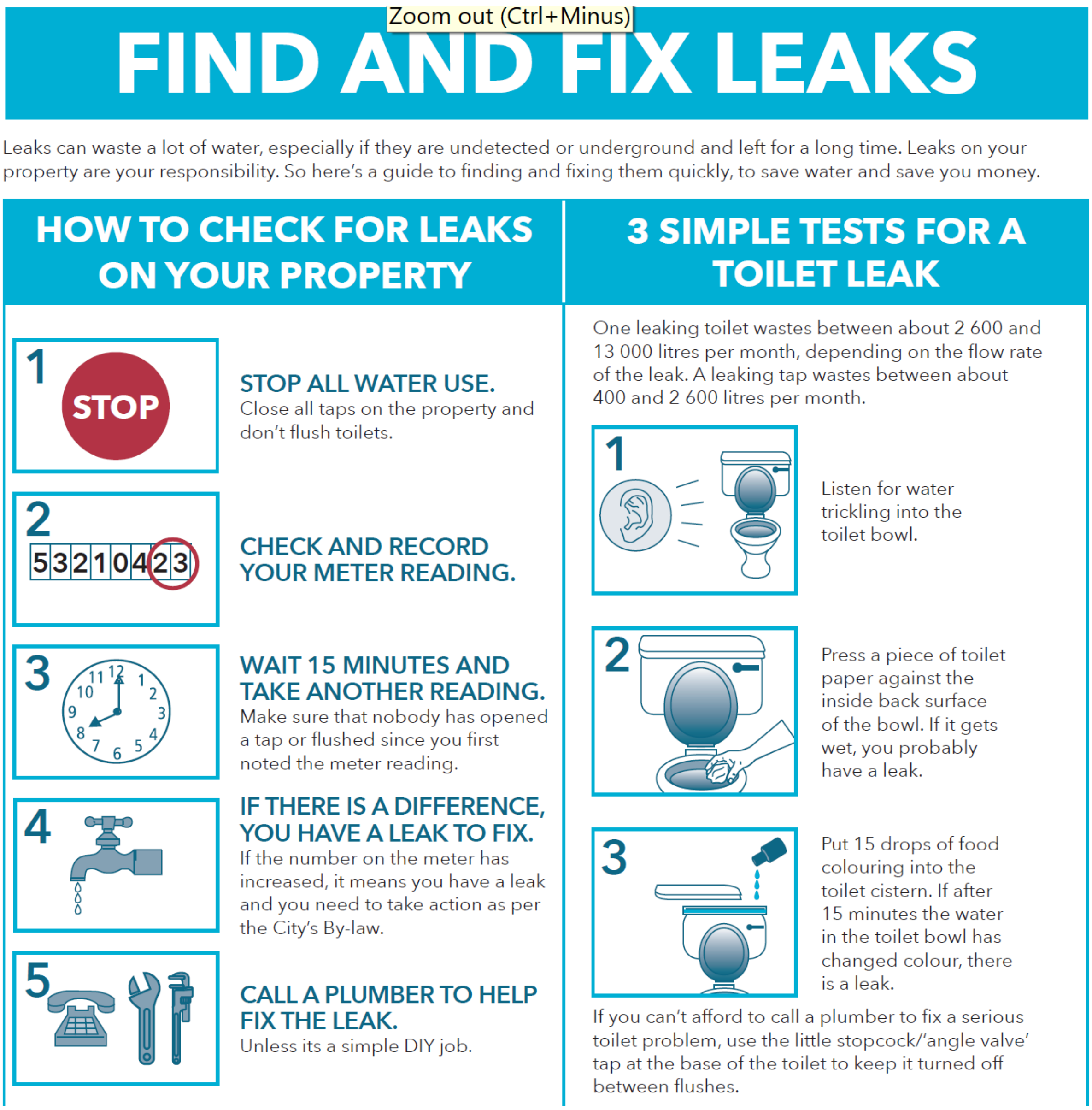
Using the cup and bucket given, measure the water used in some of the activities above. Write down your answers on the sheet provided.

Household Water Audit Sheet				
Auditor name:				
House address:				
Number of people living in the house				
Dates of Audit:				

Activity	**Options**	**Source**	**Average water use / activity**	**Place a tick or a 1 ea**
Body Washing & Personal Hygiene	Stop/start shower		*5-10 L*	
	2-minute shower		*20 L*	
	5-minute shower		*50 L +*	
	Waskom or sponge bath (basin)		*3 L*	
	Bath		*80-150 L*	
	Wash hands		*0.5-1 L*	
	Wash face		*0,5-1 L*	
	Brushing teeth using cup for water		*0,2 L*	
	Brushing teeth with tap running		*2-3 L*	
	Flushing Toilet		*6-11 L*	
Cleaning	Washing clothes (by hand)		*40 L*	
	Washing machine		*70 L*	
	Washing dishes (by hand)		*18 L Single basin* *36 L Double basin*	
	Dishwashing machine		*17-45 L*	
Food	Drink (cup)		*0.25 L*	
	Cooking (meal for 5 people)		*3 L*	

Household Water Audit Sheet				
Garden and Outdoors	Food garden (per m^2)		*4 L*	
	Using the hosepipe for an hour		*600 L*	
	Washing car with bucket		*20 L*	

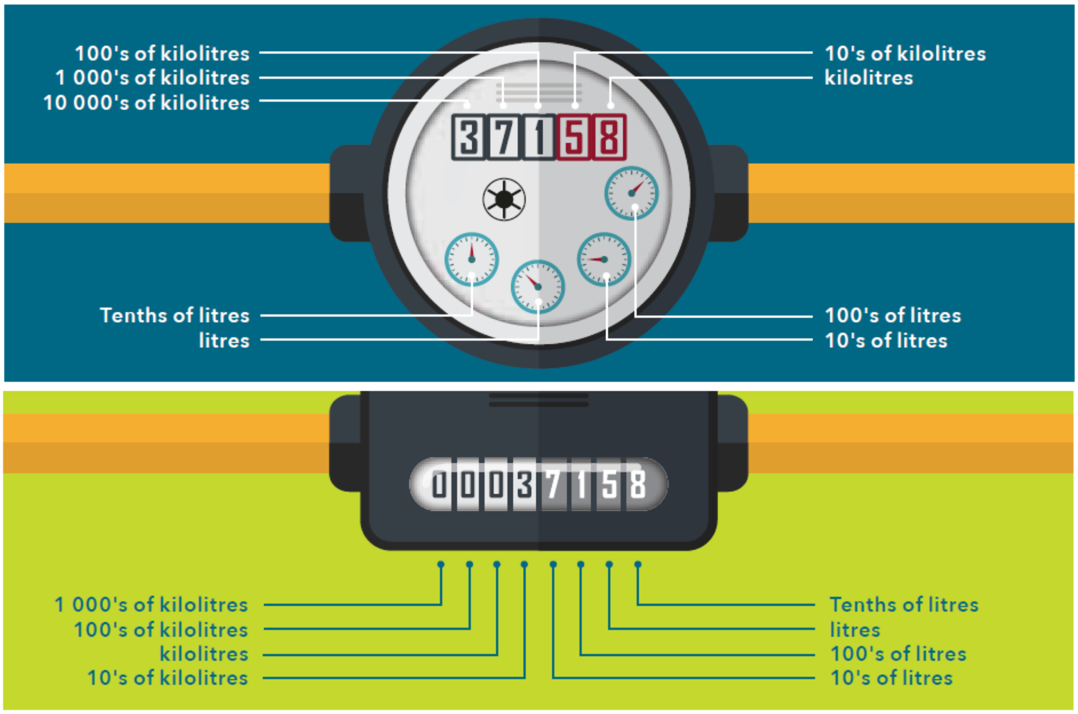
The **resources below,** and more like that**,** can be found on the City of Cape Town's website: http://www.capetown.gov.za/Family%20and%20home/residential-utility-services/residential-water-and-sanitation-services/make-water-saving-a-way-of-life



How to read your water meter

Reading a water meter is not difficult. Open your water meter box. If the meter box is locked, the City of Cape Town staff can open it with a meter box key when they come around to read your meter. Your meter is likely to look like one of two kinds used in Cape Town, which are shown below. Both record the same thing, but display the information slightly differently. The illustrations below show you how to read both kinds.

One has a set of numbers at the top and some round dials. There are various makes and models, so they might look a little bit different, but they all have these features. The other kind only has numbers and no round dials.



Note that you should particularly look for where it shows movement of the smallest volumes of water use as indicated by litres or fractions of litres, because in 15 minutes there won't be very big volumes of usage (e.g. unlikely to be 1 000 litres) On the face with round dials, look for the dials which show litres (0.001) or tenths of litres (0.0001). On the meter which just shows numbers, look to the far right of the set of numbers for where the litres (2nd from right) and tenths of litres (furthest to the right) are.

APPENDIX 12: Capacity building of the project

Table 35 Overview of current and past students and interns gaining valuable skills and competencies through their involvement in the project

	Name	Role	Gender	Nationality	Duration	Institution
CURRENT	Vumande Mjanyelwa	WRC funded Master student, WP2: Berg catchment	female	South African	Feb 2018-Feb 2020	University of Cape Town
	Thulani Ningi	WRC funded Master student, WP2 Keiskamma Catchment	Male	South African	Feb 2018-Feb 2020	University of Fort Hare
	Ntombiyenkosi Nxumalo	WRC funded Master student, WP2 uMngeni Catchment	Female	South African	Feb 2018-Feb 2020	University of KwaZulu-Natal
	Penny Price	Self-funded Master student, WP2	Female	South African	Jan 2019-Jan 2021	University of Cape Town
	Setsabile Thwala	EGS Master Student by course work	Female	South African	Aug 2018-July 2019	University of Cape Town
	Wenzile Mbanjwa	Part-time ACDI intern, support for WP3	Female	South African	June 2018-June 2019	LivingLands
PAST	Zakiya Abrahams	ACDI intern, Support WP3 + WP2 (Berg Catchment)	Female	South African	June 2018-Nov 2018	University of Cape Town
	Faryal Rohall	ACDI intern (UEA Master student), Support WP3 + WP2 (Berg Catchment)	Female	Pakistani	15 June to 5 Sept 2018	University of East Anglia
	Likho Sikutshwa	NRF intern Support WP1	Female	South African	April 2017-March 2018	University of Cape Town
	Michael Ruggeri	ACDI intern (UEA Master student), Support WP1	Male	Italian	June-Aug 2017	University of East Anglia
	Ngoni Choga	Computer Science Master Student – pilot study lower Berg catchment	Male	Zimbabwe	March 2017-Nov 2017	University of Cape Town

Table 36 Youth Community Research Assistants per site.

Local Case Study Sites	Name of Youth	ID Number
Berg catchment: Pniel & Lanquedoc	Rochelle Hendricks	8910300158088
	Lireeck Davids	9912020091085
	Sinazo Mbekwa	9407310283088
	Nolwazi Njoloza	9704260792088
Berg catchment: Velddrif	Nico Pampier	9909035528 085
	Taryn Adams	960713 0185 088
	Yvette Stroebel	960423 0168 080
	Xolani Tanta	940801 6015 089
	Felicia Bolitye	9611290880082
	Avela Qwalana	0107275474081
	Sibongile Mofokeng	9609021404081
uMngeni catchment: Sobantu and Mpophomeni	Thuleleni Nxumalo	9404021173088
	Ndumiso Celo	7111205798083
	Bonisiwe Mnguni	7806210589084
	Ntombizodwa Makena	6911220282083
	Elias Zungu	7104125728082
	Nomthandazo Sikhakhane	
	Lindiwe Mkhize	
	Bawinile Dlungwane	8502051286083
	Sibongiseni Ngubo	8502086151088
	Nhlonipho Zondo	8604065641087
	Wendy Nompilo Mthembu	9212111036087
	Mbalenhle Debbie Xaba	9001170498082
	Mlondi Mpungose (Baba-Cele)	5208095623082
	Tutu Zuma	6712300320086
	Ndumiso Mnikathi	
	Thandanani Luvuno	8003025629086
	Sindiswa Ndlovu	
Keiskamma Catchment: Hamburg	Nomasakheke Manga	8606231075082
	Dunyiswa Nxadi	8311210322080
	Pumza Magoswana	8603160642081
	Thobeka Sikiti	7309180945089
	Nomthandazo Manjezi	7511170720089

Local Case Study Sites	Name of Youth	ID Number
Keiskamma Catchment: Melani	Nomasakheke Manga	8606231075082
	Pumza Magoswana	8603160642081
	Dunyiswa Nxadi	

Table 37 Key project related capacity development events for participating students and interns.

Event	Skills/ Capacities developed	Vumande Mianvelwa	Thulani Ningi	Ntombiyenkosi Nxumalo	Setsabile Thwala	Wenzile Mbanjwa	Zakiya Abrahams	Faryal Rohall	Penny Price
Livelihoods Expert workshop 13 March 2018	Exposure how livelihoods are being conceptualized and studied in South Africa	x	x	x		x			x
2nd Research Team meeting 22-23rd March 2018	Searching for Relevant Secondary data sources Research methodologies (Constructing Questionnaires and Resource audits)	x	x	x		x			x
3rd Research Team meeting 13-14 August 2018	Revision of WEF questionnaire Feedback on proposal presentations	x	x	x	x	x	x	x	x
Training of Trainers#1 11-13 August 2018	Training on how to conduct the questionnaire and household recruitment	x	x	x	x	x	x	x	
4th Research team meeting 9 October 2018		x	x	x		x	x		
Transdisciplinary research learning and sharing workshop 29 Nov 2018		x							x
5th Research team meeting 9 January 2019		x	x	x					x
Training of Trainers#2 10 &11 January 2019	household audit method	x	x	x					
Training of Trainers#3 10 June 2019	the Resource mapping methods								
Transdisciplinary research & Ethics 22 May 2019									x
6th Research team meeting 8& 9 January 2020	Analyses of findings and cross catchment synthesis		x	x					x