Considerations for the design of nutrition-sensitive production programmes in rural South Africa

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Abstract

Background Very little has been researched about the efficacy, effectiveness, feasibility, sustainability and impact of food-based approaches on the diets and nutritional status of populations at risk of hunger and food insecurity. This study contributes knowledge about the impact of food-based approaches on the diets of populations at risk of hunger and food insecurity in four of the poorest rural communities in South Africa. The study investigated the consumption and production patterns of rural households (278 in summer and 280 in winter) in four sites in the poorest municipalities in South Africa. Methods A multistage stratified random sampling technique was applied to identify the communities and sample households for the quantitative survey and qualitative assessments. Qualitative and quantitative data were collected between 2013 and 2015 through focus group discussions (FGDs), key informant interviews and the two-round panel survey to cover both the summer and winter seasons at each site. Results Home gardening led to a significant positive increase in the consumption of white roots and tubers, dark green leafy vegetables, orange-coloured fruit and other fruit in the 24 hours prior to the survey. Participation in a community garden led to significant increases in the consumption of dark green leafy vegetables and other vegetables. School gardening did not demonstrate any statistical relationships with the consumption of foods from the crop-related food groups. Crop production improved dietary diversity. Selling produce and irrigation showed a stronger improvement in dietary diversity. Seasonality affected the availability of fresh fruit and vegetables for home consumption in winter Conclusions Producing beyond that solely for home consumption has greater benefits for dietary diversity and a consumption-smoothing effect during the post-harvest period. Politicians and the scientific community should recognise the role that household and small-scale crop production plays in supporting household consumption and the provision of essential micronutrients despite constraints and disincentives. Production and education programmes should focus on strengthening existing good consumption patterns and promoting the consumption of foods that can improve dietary diversity.

Background

Nutrition-sensitive agriculture or the production of foods with high nutrient densities (such as dairy, fish, fruit, meat and vegetables), is recognised as a pathway to improved nutrition, increasing the availability and access to nutritious foods and creating opportunities for generating income from the sale of produce (Ruel et al. 2018). Recent attention to nutrition-sensitive agriculture and food systems calls for changes in producer support programmes, the research and development system and extension practice to broaden their focus beyond the production of staple crops to the promotion and support of agricultural systems that increase the supply of nutrient-dense foods at household level and in the food system in general.

A systematic review of 169 subnational food insecurity studies conducted in the post-apartheid period in South Africa between 1994 and 2014 by Misselhorn and Hendriks (2017), found that food gardens generally play an important part in improving diet quality through the inclusion of fresh fruit and vegetables–even if only seasonally. They can also contribute to building knowledge about healthy dietary choices, build social capital and contribute to community development through enhanced networks and cooperation. However, the role of agricultural production in food security in South Africa's poorest communities has not been rigorously investigated (Misselhorn and Hendriks 2017). While there is not much evidence of widespread starvation and acute under-nutrition in the country, there is clear evidence of multiple forms of deprivation (Shisana et al. 2013). Devereux and Waidler (2017) claim that food security has certainly improved for most South Africans post-1994, but the nutrition status of children has stagnated or only improved marginally. National surveys have found significant levels of self-reported hunger, a widespread manifestation of 'hidden hunger' or micronutrient deficiencies and the co-existence of overweight and obesity alongside hidden hunger and child undernourishment (HSRC 2008; Labadarios et al. 2008; Labadarios et al. 2011b). Despite a multitude of state, private sector and NGO-funded food security programmes, stunting levels (an indication of chronic food insecurity) in South Africa increased over the Millennium Development Goal (MDG) period (National Department of Health *et al*. 2017, Hendriks *et al*. 2016). The increasing incidence of overweight among women and children raises alarm. Both the incidence of underweight and overweight indicate severe inadequacies related to the diets of South Africans.

Despite wide recognition that producing one's own food increases access to nutritious foods and can provide income to purchase other foods and non-food essentials (Ruel et al. 2018), very little has been researched or is known internationally about the efficacy, effectiveness, feasibility, sustainability and impact of food-based approaches on the diets and nutritional status of populations at risk of hunger and food insecurity (Ruel and Levin 2000). Ruel et al. (2018) report that despite growing commitment from

governments, donor agencies and development organisations to supporting nutrition-sensitive agriculture to achieve their development goals, empirical evidence on agriculture's contribution to nutrition and how it can be enhanced is still weak. Nutrition-sensitive interventions or programs are those that address the underlying determinants of nutrition and development and incorporate specific nutrition goals and actions (Ruel and Alderman 2013).

A very recent review of research findings published over the past two decades by Ruel et al. (2018) has reported that evidence on what and how agriculture can contribute to nutrition is extremely scant. Ruel et al. (2018), report that the available studies found that agricultural development programs that promote production diversity, micronutrient-rich crops (including biofortified crops), dairy or small animal rearing can improve the production and consumption of targeted commodities.

Sibhatu and Qaim (2017) report little is known about how much subsistence agriculture actually contributes to household diets and how this contribution changes seasonally. These authors point out that most studies of the pathways for improving food security through agricultural production are based on data from cross-sectional surveys that are carried out once-off at one particular time of the year. Yet, the diets of poor rural households vary seasonally. While studies of dietary adequacy and nutrition outcomes have examined the effects of seasonal outcomes of agricultural projects on women and children, little attention has been paid to understanding the seasonal variation in the consumption patterns of households engaged in agricultural production (Sibhat and Qaim 2017).

Evidence from South African studies corroborates these findings. Despite all the benefits reported in the available literature (for a review of earlier literature see Hendriks 2003 and Hendriks 2005), very little empirical evidence of the impact of agricultural production on food security in South Africa’s rural areas is available (Shisanya and Hendriks 2011). The available subnational studies with more localised samples have not used consistent approaches and do not always evaluate food security indicators directly (Misselhorn and Hendriks 2017, Shisanya and Hendriks 2011). Even less is reported on the direct nutritional impacts of production - most probably due to the lack of baseline data and weak programme/project design. Very little research has been carried out in South Africa regarding comparative food production and consumption patterns among poor rural people in South Africa.

Evidence from food security studies conducted between 1994 and 2014 in rural South Africa is not decisive regarding the role of agricultural production on food security. Mudzinganyama (2014), Selepe and Hendriks (2014), Botha et al. (2012), Beery et al. (2013), Madlala (2012), Lunga (2011), Faber and Laubscher (2008), Ndlovu (2007) and Ngidi (2007) report that gardens played a positive role in alleviating food security, while Pereira et al. (2014), Prinsloo and Pillay (2014) found that food gardens failed to play any significant role in food security (Misselhorn and Hendriks, 2017). Selepe and Hendriks (2014), Shisanya and Hendriks (2014), Beery et al. (2013), Esterhuyse (2012), Faber and Laubscher (2008) and van Averbeke and Khose (2007), report that household and community gardens can contribute to food security, but cannot assure it (Misselhorn and Hendriks, 2017).

Faber and Benade (2002), Faber et al. (2002a); Faber et al. (2002b) and Faber et al. (2011) report that crop-based interventions focusing on improving vitamin A intake increased the consumption of yellow/orange-flesh and dark-green leafy vegetables (i.e. linked to pro-vitamin A) among children in KwaZulu-Natal. Seasonal variation in the vitamin-A-rich foods consumed (including traditional leafy vegetables to supplement shortages during some times of the year) exposed the need for year-round consumption. Pereira et al. (2014), Mudzinganyama (2012) and Ngidi (2012), reiterate the seasonal constraints of improved consumption from home production.

There is some evidence that production beyond that for home consumption has greater benefits for diet quality. Mjonono et al. (2009) and Hendriks and Msaki (2009) investigated the impact of production on the food security of households belonging to a commercially engaged farmers’ organisation and a representative sample of control subsistence (producing for own consumption) households in Embo, KwaZulu-Natal, South Africa. Comparisons between producers selling to a formal supply chain, producers starting to engage in commercial production and subsistence producers showed that selling food improved household food security. These findings support earlier evidence from studies in rural South African that agricultural production can lead to beneficial dietary changes only when production goes beyond subsistence requirements (Kirsten et al. 1998; Hendriks 2003; Kirsten et al. 2007).

The evidence of the benefits of crop production on dietary diversity across seasons has not been investigated in South Africa. This study set out to compare the consumption patterns across scales of production and season in four of the country's poorest rural communities to identify practical guidance on how production could improve consumption and dietary quality across seasons. The study offered a rare opportunity for a team of transdisciplinary researchers (from agricultural economics, crop production, human nutrition and public health) and an experienced non-governmental organisation to bring their knowledge and experience together to investigate a pressing problem and find practical solutions to overcome the problem.

Methods

Using the priority districts from the Integrated Sustainable Rural Development Programme for the Eastern Cape, KwaZulu-Natal and Limpopo (Harmse 2010), and data from the Health Systems Trust's (Day et al. 2012) Deprivation Index for the North West Province, the most deprived municipalities in these provinces were selected as the sites for this study. Jozini (KwaZulu-Natal), Maruleng (Limpopo) and Ratlou (Northwest) were identified. Initially, Port St Johns Local Municipality in the OR Tambo District was selected as the area for the Eastern Cape sample, but the undulating topography and lack of farming settlements required reconsideration of this site. Ingquza Hill was selected as having the next highest poverty rate and a suitable agricultural context for the Eastern Cape site.

A mixed-methods convergent design approach (after Fetters et al., 2013), was adopted for the study. The qualitative and quantitative data were concurrently collected and analysed, with data from the quantitative survey field insights refining the initial set of focus group discussion (FGDs) and key informant interview questions. A two-round panel survey was conducted to cover both the summer and winter seasons at each site. The food security situation of the households was assessed using the anthropometry of children between 24 and 59 months and their female caregivers. A multistage stratified random sampling technique was applied to identify the communities and sample households for the quantitative survey and qualitative assessments. Enumeration area unit (EAU) orthophoto maps were obtained from Statistics South Africa (Stats SA 2003). All EAUs classified as 'traditional residential' for each district were listed. Random computer-generated numbers were used to select two EAUs per local municipality. Sample households were drawn using random computer-generated numbers from the total number of homesteads in each EAU (Table 1).

Table 1: Number of households surveyed per community

Site	Location	Summer		Winter	
		Number	Proportion of sample (%)	Number	Proportion of sample (%)
Ingquza Hill	Dubana	21	7.6	29	10.4
	KwaThahle	34	12.2	41	14.6
Jozini	Irrigation Scheme	72	25.9	40	14.3
	KwaJobe	46	16.5	44	15.7
Maruleng	Bochabelo	11	4.0	30	10.7
	Sedawa	25	9.0	30	10.7
Ratlou	Madibogo	47	16.9	49	17.5
	Phitshane	22	7.9	17	6.1
Total		278	100.0	280	100.0

Where the EAUs were the sampling frame base (for the sites in Ingquza Hill, Maruleng and Ratlou and one site in Jozini), a list of at least 100 random household numbers were generated and the households were identified and approached in the order of the random sampling list. To be included in the survey, a household had to have at least one child aged between 24 and 59 months with a caregiver present in the homestead and who was willing to participate in the study. Where a household was unavailable or did not meet the criteria for inclusion, the next household on the list was approached until at least 50 households per site were interviewed for the first round of data collection or as many households with small children had been included. Contacting the households for the second round of data collection proved tricky, leading to natural attrition in the sample size.

In the case of KwaZulu-Natal, one site was selected as per the other sites, but a second included farmers from an irrigation scheme (called Makhatini Block 6B or Mjindi). In the case of the irrigation scheme, a list of all farmers belonging to the scheme was obtained (407 members) and the households residing in Jozini (89 members) were identified. Random computer-generated

numbers were used to identify a sample of 50 households. A replacement number list was drawn where farmers could not be located, were unavailable for interviews or unwilling to participate in the survey. Due to the process of substitution of additional randomly selected members, all 69 available qualifying households were interviewed from the members of the irrigation scheme (Table 1). The University of Pretoria's Faculty of Natural and Agricultural Sciences Ethics Committee granted ethical approval for the study (approval number EC130628-066). Data were collected between 2013 and 2015 through focus group discussions, key informant interviews and the two-round panel survey to cover both the summer and winter seasons at each site. The data from the survey was cleaned, checked and descriptive and inferential statistics conducted using Microsoft Excel and SPSS Version 23 (IBM Corporation 2014).

The panel surveys were conducted at each site – one in the drier and less agriculturally productive winter months and one in the summer months. The survey captured information about household crop production, food consumption and household dietary diversity determined through a 24-hour recall and calculated using Kennedy et al's. (2011) dietary diversity index as a measure of dietary quality.

Crop-producing households were considered to be those engaged in some form of crop production, such as vegetables, fruit or industrial crops (in this case this included cotton and maize). Data were disaggregated into large-scale farming, community gardens (smaller plots on a shared commonage), school gardens where groups farm smaller plots on a larger commonage, and home gardens. Livestock production was not considered. Non-cropping households did not engage in cropping of any kind, but may have been involved in livestock production. Irrigating households were those engaged in cropping who used some form of irrigation (from buckets to irrigation scheme canals).

Focus group discussions (FGDs) were held in each community to discuss food consumption and production practices and to explore precautionary behaviour adopted when faced with food shortages. The FGDs were arranged by the NGO partner's staff in each community. Participation in the FGDs was determined by community member availability. Eighteen FGDs were held to discuss consumption and production patterns with 235 community members across the four sites. Nineteen FDGs were held to discussion production seasonality and food security, including 237 participants. The majority of FGD participants (83%) were women. The current food consumption practices and food insecurity of the households were discussed as well as changes in food production over time, together with how these changes influenced food practices. The FGDs also included simple questions around access to farming resources, including land and water to gain a general understanding of the community members' experiences as subsistence farmers. Key informant interviews were held in each community to triangulate the FGD information and deepen our understanding of the historical trends in production. The data from the qualitative analysis was captured as transcripts and content analysis was used to identify elements to investigate through the qualitative data and to explain the statistical findings.

Results

The fieldwork included both qualitative and quantitative assessment and provided rich insight into the daily lives of the communities included in the study. Figure 1 illustrates the location of the sites. The sites were significantly difference in terms of agronomy and hydrology. Table 2 presents a summary of the locations in this regard. The last two rows of the Table indicate that the time of the surveys, the rainfall at each site was within the range of the average rainfall for the location.

Table 2: Summary of agronomic and hydrological conditions

Province	KwaZulu-Natal	Eastern Cape	Limpopo	North West
District	uMkhanyakude	OR Tambo	Mopani District	Ngaka Modiri Molema
Local municipality	Jozini	Ingquza Hill	Maruleng Local Municipality	Ratlou
Agronomy	Tropical Ideal weather conditions for agricultural production. In some areas crops can grow year-round – two to three crop cycles a year are possible (Jozini Local Municipality 2012)	Coastal (mixed biome) Ingquza Hill is home to dune forests, swamp forests and coastal forests. Forests are used by local communities and receive little protection due to a lack of formal control. Subsistence agriculture is predominant (Ingquza Hill Local Municipality 2016)	Lowveld High agricultural potential with production of tropical and citrus fruit (Maruleng Local Municipality, 2012).	Grassland/semi-arid This is a semi-arid area with water scarcity.
Hydrology	Jozini Dam is a major source of drinking water for people, animals, and irrigation (Jozini Local Municipality 2012).	The area has one large river, the Umzimvubu River, two medium-sized rivers and a number of smaller coastal rivers with limited catchment areas that stretch 60 km inland. The area receives above 800 mm of rainfall a year (OR Tambo District Municipality undated).	Located on the banks of the Blyde River (Maruleng Local Municipality 2012) A large population of communal farmers is settled in an area between Hoedspruit and Tzaneen. Seven medium-sized irrigation schemes have been developed in the area, but only two remain functional.	The community is highly dependent on scarce ground water. With the existence of two river systems, one to the north and one in the centre of the area, water tables are relatively low. Borehole water is available, especially in close proximity to the river systems. Agricultural activities should also be located close to water sources (Ratlou Local Municipality 2010). There used to be a dam at Mabule, but, due to floods, it has burst its wall, resulting in the lack of a secure water supply for the villagers.
Average rainfall (Climate-Data, 2018; World Weather On-line, 2018)	569 mm	874 mm (Lusikisiki)	566 mm (Hoedspruit)	425 mm (Mabule)
Annual rainfall for round 1 (Climate-Data, 2018; World Weather On-line, 2018)	August 2012 – July 2013 (October 2013)	August 2012 – July 2013 (July 2013)	August 2013 – July 2014 (November 2014)	August 2013 – July 2014 (November 2014)
	1132 mm	1246 mm	925 mm	593 mm
Annual rainfall for round 2 (Climate-Data, 2018; World Weather On-line, 2018)	August 2013 - July 2014 (July 2014)	August 2013 – July 2014 (October/November 2014)	August 2014 – July 2015 (May 2015)	August 2014 – July 2015 (June 2015)
	924 mm	898 mm	520 mm	411 mm

The communities were located long distances from urban centres. While numerous small retail outlets and informal retailers (*spazas*) were available in the communities, households reported traveling to the nearest urban centre monthly to purchase food in bulk. During the consumption focus groups, several respondents explained that their social grants just cover the costs of the bulk monthly staples (maize meal, white flour, oil and sugar) and the minibus taxi fare to the nearest urban centre. On social grant pay-out day a proliferation of informal traders selling live chickens, eggs, freshly-butchered beef, mutton and offal, as well as fresh

produce was observed in the towns. One of the striking features of the landscape of the Ingquza Hill sites (OR Tambo District) was the vast tracts of rain-fed, terraced farmland that were formerly planted with maize and other staples, but are now in disuse. Subsistence farmers worked on small, fenced home gardens, producing vegetables and keeping a few items of small livestock. A few households still use traditional ox-drawn ploughs and sledges, but these are rare and are only used by a few enthusiastic and dedicated older people who work without much support.

Most of the surveyed households that were engaged in larger-scale crop production were in Jozini (uMkhanyakude District). No households from Ingquza Hill and Ratlou (Ngaka Modiri Molema District) were engaged in larger-scale farming (more than half a hectare). The communities surveyed in Jozini drew water from the Jozini Dam. Despite the dam, FGD focussed on the prevailing drought that significant affected rain-fed home gardening. Irrigation enables year-round production in cooperative gardens and the irrigation scheme. The participants reported that anyone with irrigation equipment could draw water from the river. The irrigation scheme, Mjindi Farming, makes the decisions about water scheme management, as it manages the scheme in Makatini.At the Maruleng site (Mopani District), agriculture appeared to play a very central role in livelihoods, perhaps more so than in the other study sites, and there seems to be more diverse and vibrant involvement in household, subsistence and smallholder production (beyond production only for household consumption), as well as a greater variety of crops and more involved local management and innovation. Overall, Maruleng producers farmed larger plots and produced more staples than the Eastern Cape and KwaZulu-Natal communities. Some households farmed maize on plots of up to six hectares. Contrary to the other sites, they reportedly produced enough maize to feed their families for the entire year without the need to purchase maize. The Mopani District has a number of small, community-managed irrigation schemes fed by mountain springs. One of these is in Maruleng near the Madeira community.

The Phitshane and Madibogo communities in the Ratlou Municipality, although 80 km apart, share the same typical arid, bushveld savannah-type landscape. With the exception of a few large farms, limited crop production was observed. The lack of engagement in agriculture was attributed to the low rainfall in recent years and the scarcity of water as nearby rivers had dried up and only a few households had access to boreholes. Many households in Phitshane did not have access to piped water in their homes and the communal taps in large sections of the village were often without water.

Rain-fed and irrigated production

The number of households engaged in crop production is presented in Table 3. While we recognise that livestock production may well contribute both food and income to rural households in South Africa, this study focussed on crop production only. Close to nine in ten surveyed households in Ingquza Hill and Jozini were engaged in crop production (90%). More than eight out of ten (82%) of the surveyed households in Maruleng were engaged in cropping. Very few households (four) surveyed in Ratlou were engaged in home gardening. All community gardens were irrigated, while 78% of farmland and 75% of school gardens were irrigated. Just less than half (47%) of home gardens were irrigated. Irrigation was taken to mean any application of supplemental irrigation – from overhead sprinklers using pumps, flood irrigation on irrigation schemes, and municipal water from taps or rain tanks (seen at many Ingquza Hill homesteads), to using a hosepipe or watering can with water drawn from rivers, tributaries, springs, wells, boreholes and tanks (Table 3).

Table 3: Households involved in crop production and irrigation

Scale of production		Whole sample		Ingquza Hill		Jozini		Maruleng		Ratlou	
		Involved in cropping	If cropping, irrigating crops	Involved in cropping	If cropping, irrigating crops	Involved in cropping	If cropping, irrigating crops	Involved in cropping	If cropping, irrigating crops	Involved in cropping	If cropping, irrigating crops
Engaged in crop production	Sample size	349	228	68	53	141	122	67	49	65	4
	Yes	242	150	61	26	126	113	51	9	4	2
	Proportion (%)	71.2	65.8	89.7	49.1	89.4	92.6	82.1	18.4	6.2	50.0
Farmland	Sample size	242	73	-	-	126	62	50	11	-	-
	Yes	75	57	-	-	64	54	10	3	-	-
	Proportion (%)	31.1	78.1	-	-	50.8	87.1	20.0	27.3	-	-
Home gardens	Sample size	242	112	61	50	126	19	51	39	4	4
	Yes	120	53	56	25	20	18	40	8	4	2
	Proportion (%)	49.6	47.3	91.8	50.0	15.9	94.7	78.4	20.5	100	50.0
School gardens	Sample size	242	4	61	2	126	2	-	-	-	-
	Yes	4	3	2	1	2	2	-	-	-	-
	Proportion (%)	1.7	75	3.3	50.0	1.6	100	-	-	-	-
Communal gardens	Sample size	242	18	61	-	126	18	-	-	-	-
	Yes	20	18	1	-	19	-	-	-	-	-
	Proportion (%)	8.3	100	1.6	-	15.1	100	-	-	-	-

The highest proportion of household gardens was found at Ingquza Hill (92% of the sample in this area). In Maruleng, 78% of gardens were home gardens. Very few households were engaged in the production of school gardens – only two in Ingquza Hill and two in Jozini (Table 3). One household in Ingquza Hill was involved in a community garden. Half of the home gardens in Ingquza Hill were irrigated. Some 19 households in Jozini were involved in community gardens, which drew water for irrigation from the Mjindi Irrigation Scheme at Makhathini. Larger plots (typically over a hectare) were farmed in Jozini (on the irrigation scheme) and mostly under rain-fed conditions in Maruleng.

Maize was reportedly produced at two school gardens in Ingquza Hill. Dry beans, carrots, maize, onions, potatoes, pumpkin, Swiss chard and sugar beans were produced in home gardens in Ingquza Hill. Far more varieties of crops were produced in Jozini and Maruleng than at the other two sites.

A very high proportion of households in Jozini irrigated their crops. This was primarily due to the availability of abundant water from the dam and a relatively high rainfall compared to the other sites. Yet still, households in Jozini complained of a lack of accessible water. The burden of accessing water in Ingquza Hill and Jozini was a major constraint to crop production. Focus group respondents in Jozini indicated that the irrigation scheme allowed for extended planting times for those participating in the scheme, with reduced water available for non-members.

Production in Maruleng was predominantly rain fed. Some 10% of home gardens in Ingquza Hill were watered with buckets from water tanks (rain harvested). While in Jozini, community and home gardens were typically irrigated with buckets of water drawn from the dam, its tributaries and rivers. Water for the community and school gardens in Jozini was sourced from the irrigation scheme. Very few households mentioned using treadle pumps, sprinklers and municipal water. Canal and flood irrigation was used in the irrigation scheme, although respondents in the FGDs indicated that there were problems with the management and allocation of water – particularly conflicting interests between commercial producers of cotton and maize who tended to dominate the

management of the irrigation scheme. Water decision-making is clearly a critical issue in the Jozini community. With a participatory management structure in place in the form of the Water Users' Association and a wide range of stakeholders that should, in principle, include subsistence, small-scale and commercial farmers, household users, tourism and recreational users, industry, as well as the municipality and tribal authorities, the dynamics are likely to be complex. Current decision-making around water does not prioritise nutrition and food security over commercial needs.

The four households with home gardens in Ratlou grew beans, cabbage, green maize and tomatoes. The crops produced in the community, school and home gardens, and on larger plots of farmland, are presented by site in Tables 4, 5 and 6.

Table 4: Crops produced in Ingquza Hill

School gardens	Home gardens
Maize	Carrots Dry beans Maize Onions Potatoes Pumpkin Swiss chard Sugar beans

Table 5: Crops produced in Jozini

Community gardens	School gardens	Home gardens	Farmland	
Amadumbe(*taro*) Beetroot Bananas Cabbage Carrots Green peppers Maize Onions Potatoes Swiss chard Sugarcane Tomatoes	Cabbage Dry beans	Bananas Green beans Beetroot Cabbage Calabash Dried beans Garlic Green peppers *Imifino*[1] Lettuce Maize Onions Potatoes Swiss chard Sweet potatoes Tomatoes	*Amadumbe* Bananas Beetroot Butternut Cabbage Calabash Carrots Cassava Dry beans Green peppers *Imifino*[1] Lemons Lettuce Maize	Mango Mealies Naartjies/ tangerines Onions Oranges Potatoes Swiss chard Sugar beans Sugarcane Sweet chillies Sweet potatoes Tomatoes

[1]Indigenous leafy vegetables

Table 6: Crops produced in Maruleng

Home gardens		Farmland
Bambara/njugo bean (*ditloo marapo*) Bananas Cabbage Cowpeas (*dinawa*) and leaves (*mokopu*) Dry beans Green beans Maize Mango *Morôtsê* (*makataan or Citrullus lanatus*)[1] Millet	Mealies (green maize) *Morogo* Morula tree Papaya/pawpaw Pumpkin Sorghum Swiss chard Sugar beans Tomatoes Watermelon	Green beans Dry beans Millet (*leotša)* Maize *Morula* *Morogo*[2] Swiss chard

[1]Melon

[2] Indigenous leafy vegetables

It should be noted that the maize typically grown by the households surveyed was either consumed as a green vegetable (referred to here as green mealies) or left to dry on the cob for use in traditional dishes for feasts, festivals and traditional ceremonies. The latter is usually ground on a millstone or at communal granaries. Where the term maize is used in this report, it is used to refer to either green mealies or dried maize. The survey did not record production of these two crops separately, but the FGDs indicated that most maize produced in school, home and community gardens is consumed as green mealies. Dried beans refer to red speckled beans that are left in the field to dry on the plant and then harvested.

Focus group participants in all communities reported climate change, which is explained as rainfall arriving earlier or later in the season and general difficulty with predicting weather conditions. A participant in a Jozini FGD explained that because of the changes in weather, sugar beans, pumpkins, peanuts, ndumbu (cassava) and peas were no longer being produced. But

… samp (maize)*, sweet potatoes, cassava, peanuts, mbila, pumpkins, mabele* (sorghum) *and sugar beans. Now people rely more on modern food, it is easier to prepare. People are interested in traditional food but it is difficult to prepare – you need to cook it at night and take the pot of the stove in the morning. Traditional food takes longer to prepare. All things that are bought - they are easier.*

Another participant from Maruleng explained that:

… We used to produce many things like nuts, watermelon, pumpkins, and others – there were locusts and other foods. There is a lack of rain and we don't gather these things anymore. The diet was more diverse, and people were healthier. We also had access to medicinal herbs such as ditloo marapo (bambara or njugo bean)*, but this is no longer around. This was our medication for diabetes and hypertension. […].*

Jozini FGD participants reported that the rain came so late in some years that their seeds did not germinate.

[...] there is the problem is rain and no irrigation water. At home, there is no irrigation but there is in the community garden that we are sharing. It has been changing – there was enough rain before; we used to use hand hoes to plant but now we have to rely on tractors, the land is hard. Previously the rainfalls were earlier, used to plant in July and rain in August, but now, by the time the rain comes the seeds have died. [...] it was very easy to farm with hand hoes, now you don't get anything, you need a tractor and if you have no money you cannot plant.

The lack of predictable weather patterns and the late onset of rain is a deterrent to home gardening, but irrigation enabled year-round production in cooperative gardens for those who could participate. According to the FGDs, those who do not have access to irrigation are the ones in the community who go hungry.

The seasonality of production was mapped through FGDs. Quite distinct patterns of production and availability of produce were evident. The diversity (or lack of it) of produce was also evident. The stark contrast between the scarcity of available produce from production in a drier area in Jozini (Hlakaniphani) and Ratlou demonstrates the necessity of water availability to improve the year-round production of vegetables. Reliance on rain-fed production constrains which crops can be planted (those that do not require lots of water and regular watering) and is a serious constraint to production in the drier months. A Jozini participant reported that:

… Even the fruit trees are not giving enough because of climate change – oranges have reduced, the spinach is no longer giving big leaves. Some of the traditional crops are no longer grown because of the changes – they used to rely on rain, even maize used to be grown on a larger scale, but no longer grown, and now there are only small vegetable plots.

An important consideration that surfaced in the FGDs was the physical drudgery of collecting water from water sources (if available). Households interviewed in the Jozini and Ingquza Hill sites raised this as an important constraint to production. In Ingquza Hill, some households paid community entrepreneurs to fetch water for their household and production uses with pick-up trucks.

Some 60% of households that engaged in farmland crop production in Ingquza Hill and Jozini had sold produce in the year prior to the survey. Just over half (54%) of the households that engaged in larger-scale crop production in Maruleng had sold produce in the same period. Almost half of the households that engaged in community garden production in Jozini had sold produce. Four to five times as many households engaged in home crop production in Jozini (45%) had sold produce in the previous year.

Table 9 shows that only three foods groups (cereals, other vegetables, oils and fats) were consumed by more than half of the households in summer, followed by roughly one in three households that included foods from the white roots and tubers, dark green vegetables, and meat and milk products groups in summer. In winter, the consumption of cereals, and oils and fats remained consistent, but the consumption of dark green leafy vegetables and meat dropped considerably. The consumption of dried legumes and milk increased in winter.

Table 7: Number of food groups consumed in the previous 24 hours

Sample	Season	Sample size	One to four food groups	Five to seven food groups	Eight or more food groups
Total sample	Summer	262	40.1	27.8	32.1
	Winter	271	40.2	39.9	19.9
Non-cropping	Summer	101	49.5	30.7	19.8
	Winter	81	51.9	40.7	7.4
Cropping	Summer	159	34.6	25.8	39.6
	Winter	187	34.8	39.5	25.7
Irrigating	Summer	95	20.2	25.1	54.7
	Winter	105	23.8	34.3	41.9
Ingquza Hill	Summer	55	58.2	30.9	10.9
	Winter	69	40.6	52.2	7.2
Jozini	Summer	116	13.8	19	67.2
	Winter	82	28.0	29.3	42.7
Maruleng	Summer	36	75.0	25.0	0.0
	Winter	56	44.6	50.0	5.4
Ratlou	Summer	55	54.5	45.5	0.0
	Winter	64	51.6	40.6	7.8

Table 8. The Household Dietary Diversity Scores from the 24-hour recall

Site	Season	Sample size	Minimum	Maximum	Mean	Standard error	Standard deviation
Total sample	Summer	159	2	14	7.4	0.327	4.122
	Winter	187	1	14	6.0	0.221	3.021
Ingquza Hill	Summer	55	2	12	4.6	0.289	2.146
	Winter	69	2	10	5.0	0.245	2.036
Jozini	Summer	116	2	14	10.2	0.378	4.070
	Winter	82	2	14	7.3	0.401	3.629
Maruleng	Summer	36	3	7	4.1	0.164	0.984
	Winter	56	2	8	4.8	0.208	1.558
Ratlou	Summer	55	1	7	4.2	0.174	1.290
	Winter	64	1	9	4.7	0.215	1.719
Non-cropping	Summer	101	1	14	6.0	0.399	4.014
	Winter	81	2	9	4.7	0.178	1.603
Cropping	Summer	159	2	14	7.4	0.327	4.122
	Winter	187	1	14	6.0	0.221	3.021
Irrigating	Summer	95	2	14	8.9	0.421	4.099
	Winter	105	2	14	7.2	0.325	3.331

Table 9: Food group consumption for cropping and non-cropping households from the 24-hour recall

	Season	Total sample		Non-cropping		Cropping		Irrigating	
		Number	Proportion	Number	Proportion	Number	Proportion	Number	Proportion
Sample size	Summer	264		103		83		75	
	Winter	279		83		193		108	
Cereals	Summer	255	96.2	99	96.1	83	100	74	98.7
	Winter	273	97.5	83	100	186	96.4	102	94.4
White roots and tubers	Summer	125 (of 265)	47.2	47	45.6	31	37.3	20	26.7
	Winter	113	40.4	31	37.3	81	42.0	58	53.7
Orange-fleshed vegetables	Summer	83	31.6	23 (of 102)	22.5	15	18.1	10	13.3
	Winter	57	20.4	15	18.1	42	21.8	31	28.7
Dark green leafy vegetables	Summer	132	50.2	39 (of 102)	38.2	20	24.1	16	21.3
	Winter	93	33.2	20	24.1	73	37.8	55	50.9
Other vegetables	Summer	196	74.2	61 (of 102)	59.8	37	44.6	45 (of 72)	62.5
	Winter	180 of 274)	65.7	37	44.6	140	72.5	89 (of 106)	84.0
Orange-coloured fruit	Summer	72	27.3	24 (of 102)	23.5	4	4.8	5 (of 74)	6.8
	Winter	35 (of 277)	12.6	4	9.6	31 (of 191)	16.2	26 (of 107)	24.3
Other fruit	Summer	100	37.9	24 (of 102)	23.5	8	9.6	16	21.3
	Winter	69	24.7	8	9.6	60	31.1	43	39.8
Organ meat	Summer	79 (of 263)	30.0	28 (of 102)	27.7	13 (of 82)	15.9	5	6.7
	Winter	32 (of 278)	11.5	13 (of 82)	15.9	19	31.1	14	13.0
Meat	Summer	140	53.0	47 (of 102)	46.1	46	55.4	28	37.3
	Winter	144	51.6	46	55.4	97	50.3	67	62.0
Eggs	Summer	76	28.8	25 (of 102)	24.5	4	4.8	4	5.3
	Winter	39	13.9	4	4.8	35	18.1	29	26.9
Fish and seafood	Summer	98 (of 263)	37.3	35 (of 101)	34.7	12 (of 82)	14.6	9	12.0
	Winter	65	23.4	12 (of 82)	4.8	53	27.5	44	40.7
Dried beans and legumes	Summer	96	36.4	25 (of 102)	24.5	8	9.6	16	21.3
	Winter	79	28.2	8	9.6	71	36.8	54	50.0
Milk and milk products	Summer	136	51.1	51 (of 102)	50.0	35	42.2	29	38.7
	Winter	124	44.4	35	42.2	88	45.6	55	50.9
Oils and fats	Summer	238 (of 265)	89.9	91	90.4	73	88.0	59	78.7
	Winter	243	87.1	73	88.0	167	86.5	99	91.7

Cropping was significantly and positively correlated with the consumption of orange-fleshed vegetables, dark green leafy vegetables, other vegetables, other fruit and dried beans and legumes (Table 10). Irrigating and farmland (larger-scale) production were positively correlated to the consumption of other vegetables, other fruit, and dried beans and legumes.

Table 10: Correlations (Spearman's) of food group consumption and scale of farming

Food group		Cropping	Irrigating	Farm- land	Home garden	School garden	Community garden
White roots and tubers	Correlation coefficient	0.027	0.073	0.084	-0.138**	0.031	0.063
	Significance (two-tailed)	0.531	0.103	0.051	0.001	0.470	0.140
	Sample size	539	506	543	545	545	545
Orange-fleshed vegetables	Correlation coefficient	0.088*	-0.027	0.083	-0.083	0.044	0.041
	Significance (two-tailed)	0.040	0.542	0.054	0.054	0.301	0.335
	Sample size	537	504	540	542	542	542
Dark green leafy vegetables	Correlation coefficient	0.142**	-0.059	0.153**	-0.194**	0.003	0.156**
	Significance (two-tailed)	0.001	0.187	0.000	0.000	0.942	0.000
	Sample size	537	504	540	542	542	542
Other vegetables	Correlation coefficient	0.264**	-0.234**	0.285**	-0.075	-0.068	0.142**
	Significance (two-tailed)	0.000	0.000	0.000	0.082	0.117	0.001
	Sample size	533	500	536	538	538	538
Orange-coloured fruit	Correlation coefficient	0.085	-0.034	0.138**	-0.172**	0.025	0.082
	Significance (two-tailed)	0.050	0.447	0.001	0.000	0.557	0.055
	Sample size	536	503	539	541	541	541
Other fruit	Correlation coefficient	0.212**	-0.121**	0.167**	-0.085*	0.029	0.081
	Significance (two-tailed)	0.000	0.007	0.000	0.049	0.501	0.059
	Sample size	538	505	541	543	543	543
Dry beans and legumes	Correlation coefficient	0.222**	-0.150**	0.134**	-0.075	-0.009	0.144**
	Significance (two-tailed)	0.000	0.001	0.002	0.079	0.835	0.001
	Sample size	538	505	541	543	543	543

** Correlation is significant at the 0.01 level (two-tailed).

* Correlation is significant at the 0.05 level (two-tailed).

Table 11: Recommendations to improve dietary intake

Food Group	Specific crops (alphabetically) * Refers to the consumption of the leaves of the crops & Presumably small quantities are eaten; thus no nutrient intake significance (flavour and diversity considerations) # Acceptability unknown	Recommendations			
		Ingquza Hill	Jozini	Maruleng	Ratlou
Dark green leafy vegetables	Beetroot* Legumes* Pumpkins* Spinach Sweet potatoes* African leafy vegetables (‘wild’ or cultivated)	Promote and strengthen existing good patterns	Strengthen existing good patterns	Promote existing good patterns	Promote existing good patterns
Other vegetables	Beetroot Cabbage Cucumber Eggplant (brinjal)# Green beans Gem squash/‘Calabash’/other squash and pumpkin Green peppers& Lettuce Onions& Tomatoes Zucchini (baby marrow)#	Promote and strengthen existing good patterns	Strengthen existing good patterns	Strengthen existing good patterns	Promote existing good patterns
Other fruit	Apples Avocados Bananas Berries Citrus fruit Figs Guava (this tree has been classified as an invader species, and although high in nutrition, should not be recommended for cultivation) Pears Pineapples Plums# Watermelons	Promote existing good patterns	Promote and strengthen existing good patterns	Promote and strengthen existing good patterns	Promote existing good patterns
Short-term: Orange-fleshed vegetables	Carrots Dark orange pumpkin, butternut or squash Orange sweet potatoes	Promote existing good patterns	Strengthen existing good patterns	Promote existing good patterns	Promote existing good patterns
Longer term: Orange-coloured fruit	Apricots Loquats Mangos Papaya Orange peaches Spanspek (cantaloupe)#	Promote existing good patterns	Promote existing good patterns	Promote existing good patterns	Promote existing good patterns

[1] This refers to potentially important crops, purely from a human nutrition perspective and keeping dietary diversity and current eating and purchasing patterns in mind.

Discussion

The majority of households consumed foods from only four to eight food groups (Table 7). The average household dietary diversity index for summer was 4.6 (standard deviation 2.14) and 5.0 (standard deviation 2.03) in winter (Table 8). All households consumed maize and so ate foods from the cereals food group. For some households, this staple food was the only food consumed. It seems though that households forgot to report the addition of salt to the cooking water in the preparation of maize porridge. Salt would be classified as a condiment in the dietary diversity assessment but as condiments are not included in the calculation of the dietary diversity index, this would not affect the analysis of dietary diversity.

Of concern was that only 32% of the households surveyed had consumed food from eight or more food groups in the previous day in summer, while 20% of the households had consumed food from these food groups in the previous day in winter. In summer, 56% of households included other vegetables (mostly tomatoes, onions, green peppers and wild/indigenous vegetables) in their meals, while 61% did so in winter. Households also consumed white roots and tubers (44% in summer and 43% in winter), dark green leafy

vegetables (29% in summer and 15% in winter) and orange-fleshed vegetables (22% in summer and 24% in winter). However, these were not consumed every day or in large quantities.

Engagement in production influenced dietary diversity. Far more cropping households consumed foods from eight or more food groups in both summer and winter (Table 9). The data presented in Table 9 show that 40% of households involved in cropping consumed foods from eight or more food groups in summer and 26% did so in winter. This was remarkably different to the non-cropping households, where only 20% consumed foods from eight or more food groups in summer and 7% did so in winter. Over half (55%) of irrigating households consumed foods from eight or more food groups in summer and 42% consumed these foods in winter. Even though most foods were purchased, cropping increased the availability of foods for home consumption.

The analysis does not indicate a strong influence of crop production on the consumption of fruit and vegetables in summer (Table 9). However, proportionally fewer cropping households consumed orange-fleshed vegetables in summer, but consumed more than non-cropping households consume in winter. The same pattern was seen for the consumption of dark green leafy vegetables, other vegetables, orange-coloured fruit, other fruit, as well as dried beans and legumes. This shows a more positive influence of cropping on the consumption of fruit and vegetables in winter than in summer. This result was not expected, as the number of crops that can produce edible portions in winter is rather limited. Some crops such as beans are produced in summer and preserved (dried) for consumption in winter. The cultural preference is for dried beans rather than fresh green beans. Crops such as pumpkin and butternut are also stored for consumption later. Another explanation may be that savings from consumption in summer were used to purchasing these foods in winter, post-harvest. This was certainly true for households engaged in farmland cultivation (larger scale production) where consumption patterns improved in winter, post-harvesting of the main crops. However, farmland cultivation was only carried out under irrigated conditions.

The dietary diversity of non-crop-producing households was lower than that of crop-producing households in both winter and summer (Table 8), and decreased by at least one food group in winter. Households engaged in cropping had higher average Household Dietary Diversity Scores (HDDS). Irrigation increased the average HDDS of crop-producing households even further. The HDDS for irrigating households increased from an average of 7.1 food groups in summer to 8.9 in winter; probably due to the availability of income from the previous season that enabled the purchasing of more diverse foods in winter.

Income from farmland production and irrigated agriculture led to increased intakes of fruit and vegetables in general, but also meat, eggs, fish, milk, roots and tubers. This shows that there is potential for greater improvement in dietary diversity and quality if households scale up production to produce enough food to sell.

Home gardening led to a significant positive increase in the consumption of white roots and tubers, dark green leafy vegetables, orange-coloured fruit and other fruit in the 24 hours prior to the survey (Table 10). Participation in a community garden led to significant increases in the consumption of dark green leafy vegetables and other vegetables. School gardening did not demonstrate any statistical relationships with the consumption of foods from the crop-related food groups.

Conclusions

This is the first comparative paper between the poorest communities in South Africa. The findings show that, contrary to popular opinion and rhetoric, a significant number of households in South Africa's poorest rural communities were engaged in production at some level, supplementing their diets in the areas where crop production was possible (Ingquza Hill, Jozini and Maruleng). Very few households engaged in agriculture in Ratlou due to the aridity of the area.

The study found an encouraging link between engaging in agriculture and diet quality. Engagement in crop production increased the availability of vegetables and, in some cases, fruit (when in season). This improved households' dietary diversity. Income from farmland production and irrigated agriculture led to increased intakes of fruit and vegetables in general, but also of meat, eggs, fish, milk, roots and tubers. However, the scale of production and year-round availability was a constraint to accessing an adequately diversified diet.

Yet, without marketing opportunities at both at the community and food system level, there are few incentives to increase the production of these crops beyond home consumption. Yet, our findings show that producing beyond that solely for home consumption has greater benefits for dietary diversity and a consumption-smoothing effect during the post-harvest period. It is

therefore, essential that policies and programmes pay attention to the development of market infrastructure and linkages to markets for the uptake of produce.

Rather than perpetuating the rhetoric of deagrarianisation and claiming that social grants are a disincentive to production in South Africa's rural areas, it is essential for politicians and the science community alike to recognise the role that household and small-scale crop production plays in supporting household consumption and the provision of essential micronutrients. The study shows that people continue to produce food in these communities despite the constraints and disincentives. Crop production, along with educational programmes to promote the diversification of diets should be supported in South Africa's rural communities. Combined with social grants that help purchase basic food staples and other non-food goods and services, production can fill nutrient gaps, improving dietary quality and offering opportunities for incomes when scaled beyond production for home consumption.

From the findings, we are able to recommend that production and education programmes focus on s*trengthen* existing good consumption patterns and *promoting* the consumption of foods that can improve dietary diversity. Table 11 presents a list of potentially important crops for each area that could improve food consumption, based on the eating and purchasing patterns of the communities investigated.

Table 11: Recommendations to improve dietary intake

Food Group	Specific crops (alphabetically) * Refers to the consumption of the leaves of the crops & Presumably small quantities are eaten; thus no nutrient intake significance (flavour and diversity considerations) # Acceptability unknown	Recommendations			
		Ingquza Hill	Jozini	Maruleng	Ratlou
Dark green leafy vegetables	Beetroot* Legumes* Pumpkins* Spinach Sweet potatoes* African leafy vegetables ('wild' or cultivated)	Promote and strengthen existing good patterns	Strengthen existing good patterns	Promote existing good patterns	Promote existing good patterns
Other vegetables	Beetroot Cabbage Cucumber Eggplant (brinjal)# Green beans Gem squash/'Calabash'/other squash and pumpkin Green peppers& Lettuce Onions& Tomatoes Zucchini (baby marrow)#	Promote and strengthen existing good patterns	Strengthen existing good patterns	Strengthen existing good patterns	Promote existing good patterns
Other fruit	Apples Avocados Bananas Berries Citrus fruit Figs Guava (this tree has been classified as an invader species, and although high in nutrition, should not be recommended for cultivation) Pears Pineapples Plums# Watermelons	Promote existing good patterns	Promote and strengthen existing good patterns	Promote and strengthen existing good patterns	Promote existing good patterns

Food Group	Specific crops (alphabetically) * Refers to the consumption of the leaves of the crops & Presumably small quantities are eaten; thus no nutrient intake significance (flavour and diversity considerations) # Acceptability unknown	Recommendations			
		Ingquza Hill	Jozini	Maruleng	Ratlou
Short-term: Orange-fleshed vegetables	Carrots Dark orange pumpkin, butternut or squash Orange sweet potatoes	Promote existing good patterns	Strengthen existing good patterns	Promote existing good patterns	Promote existing good patterns
Longer term: Orange-coloured fruit	Apricots Loquats Mangos Papaya Orange peaches Spanspek (cantaloupe)#	Promote existing good patterns	Promote existing good patterns	Promote existing good patterns	Promote existing good patterns

[1] This refers to potentially important crops, purely from a human nutrition perspective and keeping dietary diversity and current eating and purchasing patterns in mind.

The findings call for more carefully designed production support programmes that go beyond a focus on maize production to cover the production of fruit and vegetables in a variety of production systems (from rainfed production to innovative and water-saving techniques such as vertical gardens). Support should include the provision of basic water harvesting and irrigation infrastructure, greater access to quality inputs and appropriate extension support.

To overcome the seasonality constraints, research is needed to investigate what nutritious crops can grow in these areas as well as the potential for the development of early- and late-maturing crops to extend the growing season and make food from own production available for longer periods. As many of the households were engaged in home production, the development and testing of technologies and practices that are appropriate to home and small scale production conditions (including pest and disease management) should be prioritised by researchers, government programmes and extension agents.

Water harvesting practices and systems for the delivery of water to gardens are essential to enable food production in more homes and the availability of water for irrigation in winter. The provision of boreholes and piped water is essential in drier areas such as Ratlou, although production in such areas will always require extensive amounts of water.

Abbreviations

EAU Enumeration area unit

FDG Focus Group Discussion

HDDS Household Dietary Diversity Score

Declarations

Ethics approval and consent to participate

Ethics approval for this study was obtained from the University of [removed for review], reference number EC130628-066. All participants completed and signed an informed consent form prior to the interviews.

Consent for publication

Not applicable.

Availability of data and material

The data that support the findings of this study are available from the corresponding author, [Removed for review], upon reasonable request. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

Competing interests

Dr. Sheryl L Hendriks is an Associate Editor of the BMC Public Health Journal.

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Authors' contributions

All authors have read and approved the manuscript.

SH – project conceptualisation, project leader, design of methodology, survey design, analysis and interpretation of data, drafting of manuscript.

AV - design of methodology, survey design input, fieldworker training, interpretation of data, revision of manuscript

DM - survey design input, interpretation of data, revision of manuscript

FAMW - design of methodology, survey design input, fieldworker training, interpretation of data, revision of manuscript

AMM - design of methodology, survey design input, data collection, interpretation of data, revision of manuscript

MSN - design of methodology, survey design input, fieldworker training and oversight, data collection, interpretation of data, revision of manuscript

JGA - survey design input, interpretation of data, revision of manuscript

MK - survey design input, revision of manuscript

DS – community interaction and introductions, survey design input, interpretation of data.

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Figures

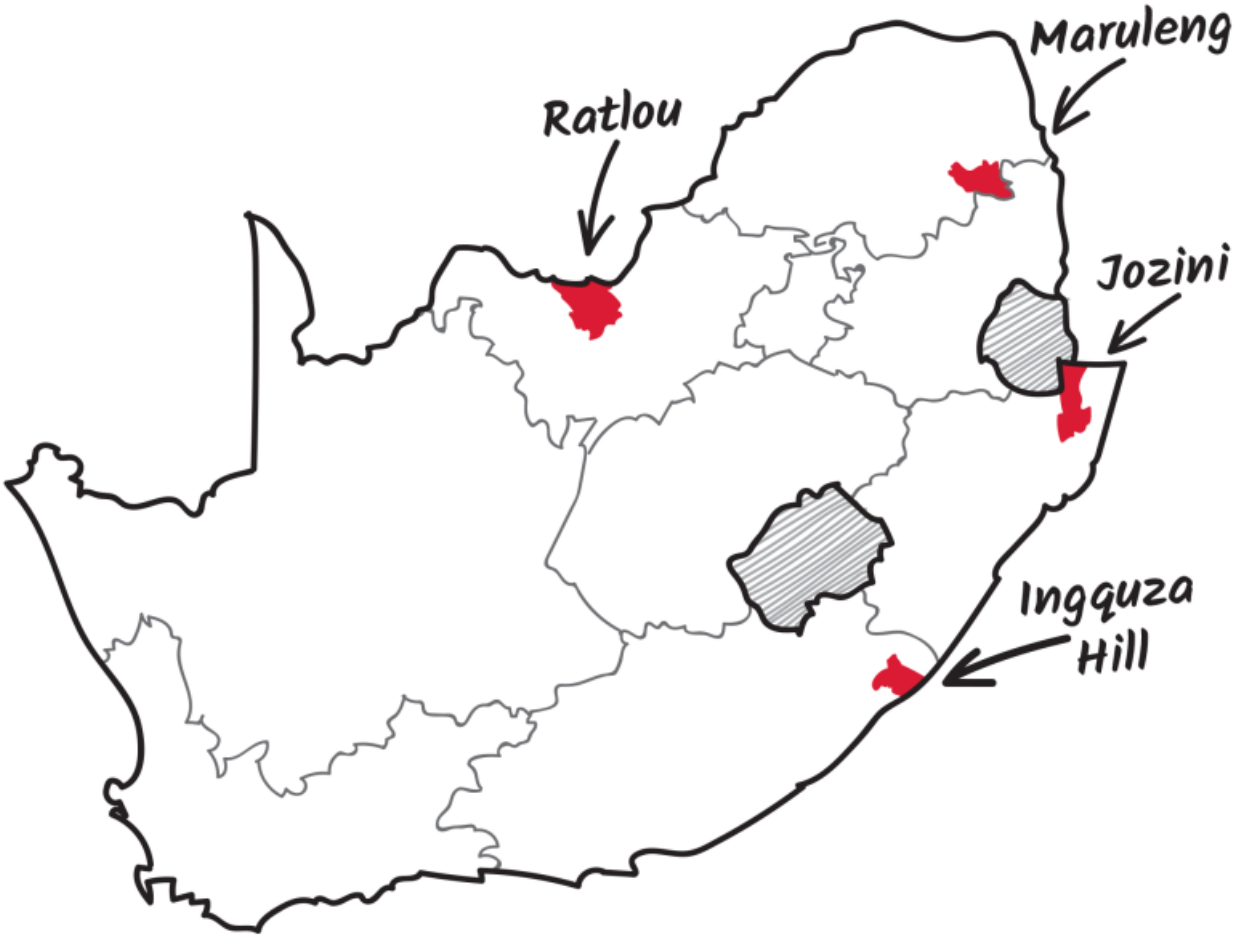

Figure 1

Map of the study areas (authors's own image)

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