Int J Disaster Risk Sci (2014) 5:313–322
DOI 10.1007/s13753-014-0032-3

www.ijdrs.com
www.springer.com/13753

ARTICLE

Built-in Risk: Linking Housing Concerns and Flood Risk in Subsidized Housing Settlements in Cape Town, South Africa

Robyn Pharoah

Abstract As in many other settings in developing countries, discussions on urban flooding in South Africa tend to focus on informal settlements. There is less attention to poor but formal housing areas, based on the largely untested assumption that the formalization of housing addresses risk. This is at odds with an extensive literature from the housing and developmental sectors that highlights weaknesses in the location and construction of low-income housing, particularly state-subsidized housing. Drawing on research in 10 poor, flood-prone settlements in Cape Town, South Africa, this article explores whether providing housing addresses risk. The results show that flooding remains a challenge in subsidized housing areas and that risk is linked strongly to the buildings themselves. Poorly designed and constructed dwellings perpetuate risk in low-income areas. While divorced conceptually and practically, disaster risk and housing issues are critically linked, and housing concerns must be factored into discussions on flooding in Cape Town and comparable settings elsewhere.

Keywords Cape Town · Flood risk · Subsidized housing · Urban housing

1 Introduction

Flooding is a perennial problem in Cape Town. Heavy winter rainfall frequently results in flooding between May and September. An assessment carried out in 2004 shows that 24 significant flood events occurred in Cape Town between 1989 and 2004 (DiMP 2005). More recent estimates suggest that between 32,000 and 34,000 people were displaced by flooding in informal settlements each year during the winters of 2007, 2008, and 2009 (Ziervogel and Smit 2009).[1] This flooding seldom claims lives, but results in significant damage to property, roads, and infrastructure. It is estimated that one major flood event in August 2008 alone cost the city at least R 4.9 million (approximately USD 700,000) in damage just to coastal amenities (DiMP 2010) and its citizens untold indirect losses. "Rising flooding" due to the high water table in some areas is a particular concern.[2] Others include flooding as a result of urban sprawl into wetlands and other flood-prone areas.

Both international and local discussions on risk generally, and flooding specifically, tend to focus on informal settlements. It is assumed that flooding is most common and most severe in Cape Town's more than 200 informal

R. Pharoah (✉)
Research Alliance for Disaster and Risk Reduction (RADAR), Stellenbosch University, Matieland 7602, South Africa
e-mail: robynpharoah@sun.ac.za

---

[1] Informal settlements refer to settlements that fall outside of the government's planning processes. Unlike formal settlements, which are characterized by formal site planning and service infrastructure, informal areas are entirely unplanned and have little or no infrastructure. As used in South Africa, the term is analogous to shanty towns. Informal settlements are technically illegal, but residents are protected by legislation granting them de facto tenure rights by virtue of living on the land. They have tended to be unserviced spaces, but where they are located on government-owned land, the authorities increasingly provide basic services, including communal toilets and water taps, and refuse collection from communal tips. Informal dwellings tend to be rudimentary, makeshift structures, and are often built using combinations of corrugated iron, plastic, and wood.

[2] "Rising flooding" or seepage occurs when groundwater upwells through dwelling floors due to a high water table. This problem is common in informal settlements on the Cape Flats, where dwellings in low-lying areas may be inundated with several inches of water for much of the rainy season.

settlements (DiMP 2005; Bahry 2007; Bouchard et al. 2007; DiMP 2009a, b, c; Ziervogel and Smit 2009; Drivdal 2011a, b). Although few authors or practitioners explicitly link disaster risk reduction and the provision of subsidized housing, the implicit assumption is that providing poor households in informal settlements with formal brick and mortar dwellings solves a range of developmental problems, including flood risk.

This is at odds with an extensive and well-established literature, focused primarily on developmental and housing concerns, documenting flaws in South Africa's subsidized housing program. Not only are many settlements built on risk-prone land, but settlements and dwellings are frequently poorly designed and constructed, suggesting the potential for continued exposure and vulnerability to floods and other hazards. However, the literature on housing and flooding has not explored adequately the possible connection between the quality of subsidized housing and flood risk. There has been virtually no research on flooding in low-cost housing areas (the term subsidized housing and low-cost housing are used interchangeably in this article), and no exchange of ideas between professionals working on housing and those working on disaster risk reduction issues.

This article explores the extent to which subsidized housing areas experience flooding and the drivers of risk. It examines the experience of flooding in subsidized housing areas on Cape Town's Cape Flats, an impoverished and flood-prone plain on the outskirts of the city. Drawing on research in 10 communities, it shows that flooding is not confined to informal settlements. It also illustrates that risk is linked to the built environment, and that poorly designed and constructed dwellings serve to perpetuate flood risk in low-cost housing areas. The article begins by discussing the core elements of the South African government's subsidized housing program and the challenges it faces. It then describes the research methodology and approach, followed by an examination of the extent and drivers of risk in the settlements, and the implications for how we understand flooding in Cape Town and comparable settings elsewhere.

2 South Africa's Subsidized Housing Program

South Africa's housing policy is one of the government's most important redistributive programs (Pieterse 2009). The provision of housing has been a key component of the government's efforts to improve the lives of poor South Africans since it came to power in 1994. It has also become an important political imperative, as the authorities seek to "demonstrate delivery to an expectant post-democracy constituency" (Charlton 2009, p. 302).

The housing program aims to provide low-income households with homes by providing subsidies to help build or purchase entry-level housing. Under the Reconstruction and Development Program (RDP), launched in 1994, targeted subsidies were primarily used to fund new low-cost turnkey housing developments—so called "RDP houses." The subsidies could also be used for self-help construction on fully serviced sites, referred to as the People's Housing Process (PHP) (Del Mistro and Hensher 2009). Its more recent iteration, the comprehensive plan for sustainable human settlement (often referred to as the breaking new ground (BNG) plan), which was incorporated into the National Housing Code in 1994, seeks to provide more varied and responsive housing options, including social housing, flats, group housing, and hostels (Department of Housing 2004). It emphasizes the eradication of informal settlements through phased, in situ upgrading in locations suitable for development, and relocation to greenfield sites in areas where development is not possible or desirable, such as areas with unfavorable soil conditions (Department of Housing 2004).

The program has successfully provided millions of poor South Africans with homes, but has also faced challenges. In many instances settlements are built on marginal land. As Huchzermeyer (2003, p. 130) argues, housing projects "perpetuate segregation by income group, allocating the most disadvantaged urban/peri-urban locations to the poorest sectors of society […] in places where no high income earner will wish to locate." Dwellings have also been criticized for being poorly designed and constructed and badly finished (Gilbert 2004; Smith 2008; Bolnick 2009; Charlton 2009; Tomlinson 2011). Most pertinent to the flooding issue, dwellings frequently show structural flaws, lack basic weatherproofing, and are prone to leaks. Studies highlight problems, such as large, visible cracks, dampness, the absence of plastering (Govender et al. 2011; Ntema n.d.), poorly laid and inadequately waterproofed floor slabs (Ngxubaza 2010), and poor ventilation and thermoregulation (Aigbavboa and Thwala 2011). Data from Statistics South Africa's 2011 General Household Survey (Statistics South Africa 2011) also highlights problems, particularly in the Western Cape. One out of three households living in subsidized housing in the province reported that their roofs (32 %) and walls (32 %) were "weak" or in need of minor repairs (both 32 %).

3 Research Methodology and Approach

The study compared the experiences of households in five informal and five subsidized housing areas. The research was conducted between October 2010 and February 2011. Three of the research sites (two subsidized housing areas, New Rest and Luyoloville, and one informal settlement, Kanana) were located in Guguletu, with the remainder in Philippi, both areas where flooding is common. The informal settlements were selected from a list of the 20 most flood-prone settlements generated by the city's Disaster Risk Management Centre (DRMC) each year in the run-up to winter. Working on the assumption that neighboring sites are likely to share at least some of the same physical vulnerabilities, such as topographical features, subsidized housing sites were chosen for their proximity to the informal sites (Table 1).

The research team collected a combination of qualitative, quantitative, and spatial data. The qualitative component included a focus group discussion in each site, with a mixed group of 6–12 adults from the settlement, interviews with community leaders, and walks through each of the areas. This informed the design of a survey, administered to 500 households (250 in informal and subsidized housing areas respectively, and 50 randomly selected households in each site). The spatial component collected information on topographical factors such as proximity to natural water bodies and manmade features like drainage infrastructure.

Settlements representing different housing models were chosen to assess the extent to which settlement type influences vulnerability. The sample included three contractor-built settlements (two informal settlements that had been upgraded in situ and one greenfield project), one settlement developed under the government's PHP and one mixed in situ upgrade and PHP settlement. The study was not primarily concerned with comparing dwellings built under the various housing models, but the different housing types allude to potentially influential dynamics, such as differences in the design of dwellings and settlements, the quality of buildings and their location. While subsidized housing areas are generally highly standardized and uniform in layout and design, PHP settlement respondents in PHP developments, for instance, could plausibly have greater input into how their houses and settlements were designed and the types and quality of the materials used.[3]

Table 1 Research sites of the study: Selected informal and subsidized housing areas in Cape Town, South Africa

Informal site	DRMC ranking	Linked formal site	Housing model
Kosovo	1	Samora Machel	Contractor-built
Sweet Home	2	Vukuzenzele	People's Housing Process (PHP)
Never–Never (Area K)	3	Better Life (Philippi Park)	Contractor-built in situ upgrade
Phola Park Philippi	10		
Kanana (Guguletu)	5	New Rest (Guguletu)	Mixed in situ upgrade and PHP
		Luyoloville (Guguletu)	Contractor-built

The analysis comprised three layers: a descriptive analysis of the quantitative data, statistical modeling of the survey information using SPSS, and mapping flood incidence against the topographical information. The descriptive analysis examined the extent and nature of flooding in both subsidized and informal households, while the statistical and spatial analyses focused on the drivers of risk in subsidized housing areas. The statistical analysis used binary logistic regression analysis to explore the role of architectural, physical, and socioeconomic factors in determining flood risk, and the relative importance of different factors. The spatial analysis examined the role of geographic factors. In addition to informing the design of the survey questionnaire, the qualitative information was used to deepen and understand the quantitative and spatial findings.

4 Quantitative Analysis

Flooding comprises a range of different event types, particularly in urban areas. An emerging body of literature on urban flood risk in Africa suggests that flooding spans conventional flood types, such as coastal and riverine flooding, and those rooted in underdevelopment, poor planning and inadequate building standards (Action Aid International 2006; Bouchard et al. 2007; DiMP 2007, 2008; Drivdal 2011a, b; Sakijege et al. 2012). Drawing especially on Benjamin's (2008) flood typology for the Western Cape, and the information gathered during the qualitative research, respondents were asked about five categories of flooding:

- Run-off from roads, streets, or slopes;
- Overflowing drainage infrastructure;
- Ponding;[4]
- A rising water table, or seepage; and
- Flooding due to leaking roofs, walls, doors, and window frames.

The statistical analysis examined households' experience of flooding against four broad clusters of factors:

---

[3] For the most part, subsidized housing settlements comprise small, architecturally standardized, A-frame box-type structures with a kitchen and living area, a bathroom, and two bedrooms. Most are single-story freestanding dwellings, frequently separated by narrow corridors (Bolnick 2009).

[4] Ponding refers to the persistent accumulation, or ponding, of water in low-lying areas.

- Geographical characteristics such as elevation;
- The physical-architectural characteristics of the dwelling, such as the extent to which the roof overhung external walls;
- The socioeconomic characteristics of the household; and
- Other features, such as the amount of time taken to build the dwelling, and whether the household adopted measures to mitigate rain-related problems.

The five flood types were grouped into clusters of variables likely to be rooted in similar issues:

- *Run-off* including water running into the dwelling from roads, streets, or slopes; water running into the dwelling from drainage ditches or canals; and water pooling in the yard or around the dwelling.
- *Seepage* water or dampness coming up through the dwelling's floor.
- *Structural issues* including water entering the dwelling through leaks in the roof or walls, or from around the doors and window frames.

Table 2 summarizes the particular bundle of factors examined for each type of flooding examined. All three analyses included variables on households' socioeconomic characteristics, whether the settlement was contractor-built or developed under the PHP, and whether households had adopted measures to mitigate rain-related problems. The analysis for run-off included additional attributes on the spacing of dwellings and other characteristics that could make them prone to run-off, such as their proximity to slopes or the height of the floor relative to the surrounding ground. The models for seepage included indicators on the material used for the floor, and working on the assumption that houses built very rapidly are likely to be of a lower quality than those built more slowly, the average time taken to build the dwelling. The models for structure-related flooding contained the most numerous and detailed variables. These included the materials for the roof, floor, and walls, roof features, the height of the floor, the spacing of dwellings, and the time it took to build the dwellings.

The regression analysis used forward and backwards stepwise likelihood ratio (LR) methods. The resulting models were then assessed for outliers and residuals to assess their accuracy. The process involved three steps:

- *Analysis of multicollinearity* This initial step used correlation analysis to identify and address multicollinearity between variables, with the model adjusted to address it.[5]
- *Backwards and forwards LR stepwise regression* The selected variables were run against the data on households' experience of different kinds of flooding. The models were run using both backwards and forwards methods in order to assess their stability.[6] The models produced by the forwards and backwards procedures were compared and the strongest selected for interpretation. In all cases, this comprised those produced through the backwards stepwise procedure.
- *Diagnostic analysis of the models* The final models were assessed for outliers and overly influential cases to ensure they fitted the data well and were not biased by a few cases. This involved obtaining and analyzing residual and influence statistics for all the cases represented in the model. Major outliers and unduly influential cases were assessed for errors and/or reasons for their differentiation. These were in some cases removed to improve the accuracy of the model, but only in extreme cases.[7]

Together, these measures should have served to reduce the influence of methodological issues on the models, and improve their integrity. Stepwise methods have been criticized for relying solely on mathematical criteria to build models, but they are useful in exploratory research where large numbers of variables make the model-building process computationally intensive and demanding (Katya Mauff, Statistical Consultant, Department of Statistical Sciences, University of Cape Town, personal communication, August 2011). It was felt that this strength outweighed the limitations of the method.

---

[5] Multicollinearity exists where there are strong correlations between two or more predictor variables. This makes it difficult to assess statistically which variable is actually producing a given effect (Field 2005).

[6] In the forwards method, the computer program adds variables to a baseline, constant-only model by testing which factors significantly improve the predictive capacity of the model. The backwards method does the opposite, using slightly different statistical tests. The program starts with all the test variables in the model, and progressively removes those that do not influence the model's predictive capacity. A similar outcome in both the forwards and backwards models shows internal consistency (Katya Mauff, Department of Statistical Sciences, University of Cape Town, personal communication, August 2011).

[7] Outliers were identified on the basis of their standardized residual values, while influential cases were identified using their predicted values, Cook's distance statistics, leverage values, and their DFBeta values. Following Field's (2005) suggestion, standardized residual values close to and over 3 were examined, as were Cook's distance values over 1. Appropriate leverage values were calculated using the formula $(k + 1)/N$, where k was the number of predictors and N the sample size.

Table 2 Summary of variables used in the regression analysis by problem type

Variable type	Variable	Run-off	Seepage	Structural issues
Location	Elevation (m above sea level)	x	x	x
	Proximity to a noticeable slope (yes, no)	x	x	
Dwelling	Housing model (contractor-built, PHP)	x	x	x
	Main material used for the walls (plastered, unplastered)			x
	Main material used for the floor (cement, other)		x	x
	Height of floor relative to ground/street level (above, same, below)	x		x
	Main material used for the roof (corrugated iron, tiles, asbestos)			x
	Type of roof (flat, sloped, A-frame)			x
	By how much the roof overhangs the exterior walls (30 cm or less, 31 cm or more)			x
	Space between house and neighboring dwellings (50 cm or less, 51–100 cm, 101 cm or more)	x		
Socioeconomic features	Gender of the household head	x	x	x
	Age of the household head	x	x	x
	Average monthly income per capita	x	x	x
Other	Average building time (days)		x	x
	Involvement in shaping and monitoring construction (very, somewhat, not at all)			x
	Mitigation measures (adopted type-specific measures, not adopted)	x	x	x

5 The Experience of Flooding in Subsidized Housing Areas

The findings show that not only do formal areas experience flooding, but that it is common. While just over half (59 %) of those who experienced flooding lived in an informal settlement, two fifths (42 %) lived in a formal, low-cost settlement. Considered as a proportion of those living in each type of housing, the results show that 230 (92 %) of the households surveyed in the informal sites and 163 (65 %) of those interviewed in the subsidized housing areas experienced some kind of flooding.

However, the findings show considerably more variability in the subsidized sample. As Fig. 1 shows, households in some of the subsidized housing sites were substantially more likely to experience problems than others. Although the proportion of respondents reporting leaks, seepage, and run-off in Luyoloville and Samora Machel was comparable to the informal settlement sites, only 18 % reported problems in New Rest, with Better Life (66 %) and Vukuzenzele (56 %) falling between these two extremes.

In keeping with the housing literature, the results also suggest that flooding impact in subsidized housing areas has a critical building-related component. While households living in informal settlements were most likely to experience “rising flooding” (74 %), and to a lesser extent leaking roofs (57 %), those living in subsidized housing experienced problems stemming from poorly built and finished dwellings. These included structural cracks, unfinished roofs, holes, and cracking in both the plaster and concrete around doors and windows. Respondents in subsidized housing most often reported leaking walls (61 %), followed by leaking around or through doors and windows (52 %), and seepage (41 %).

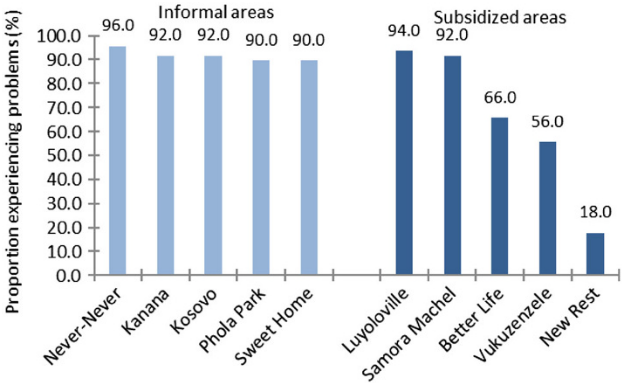

Fig. 1 The reported incidence and average number of rain-related problems by study area settlement in Cape Town, South Africa

This link is illustrated qualitatively by the markedly different experiences of respondents living in the three adjacent sites in Guguletu (Kanana, Luyoloville, New

Fig. 2 The location of Kanana, Luyoloville, and New Rest settlements in Cape Town, South Africa

Rest). All three settlements lie on reclaimed land, adjacent to wetlands, and to one another (Fig. 2). Despite their proximity, the three settlements show very different risk profiles. The DRMC identifies Kanana as among the most flood-prone informal settlements on the Cape Flats. Households in Kanana experience seepage, leaks when rain is accompanied by high winds, and some run-off. However, adjacent New Rest experiences few problems, despite sharing the same geographical conditions. Prior to its upgrading, New Rest informal settlement was included in the DRMC's list of high-risk settlements—appearing in the City of Cape Town's winter preparedness strategy as recently as 2009 (Ziervogel and Smit 2009). Luyoloville, by comparison, experiences high levels of seepage, run-off, and leaks, with the latter linked to the construction and finishing of dwellings rather than to wind.

The most obvious explanation for these differences between the sites is the design and quality of dwellings. New Rest's transition from a high-risk informal settlement to a low-risk formal one suggests a well-built development, designed and engineered in a manner appropriate to its location. It shows that subsidized housing can overcome spatial and geographical disadvantages when built to a high standard—although even New Rest experiences some problems, implying that weaknesses in processes and implementation remain even in "successful" developments. The persistent problems in Luyoloville suggest a poorly prepared site and poor design and building quality.

This hypothesis is supported by the qualitative data. Luyoloville was established in 2000, and was built by the Cape Town Community Housing Company (CTCHC). In common with several other developments built under the auspices of the CTCHC since 1999, tenure, procedural issues, and quality issues have plagued the settlement. Research conducted in 2006 uncovered reports of poor building practices, including hastily prepared floor slabs and inadequate monitoring (Zweig 2006).[8] Focus group participants in the study presented here linked the high levels of seepage in Luyoloville to poorly laid floor slabs, slabs that were too thin, and problems with the cement mix. There were also clear flaws in how houses were designed. While all the dwellings had gutters, for instance, these emptied onto a concrete apron surrounding the building and not into a drain, resulting in pooling around the dwelling. This problem was worsened in some properties by poorly laid aprons, which sloped slightly towards the building or were positioned below the surrounding ground, drawing water towards the dwelling.

These results are also supported by the statistical analysis. While one might expect dwellings in lower-lying parts of settlements or near slopes to experience higher levels of run-off,

---

[8] Zweig's research suggested that eight settlements, including Luyoloville, were not built according to the terms of the National Housing Code, and were never inspected, allowing for the use of poor-quality materials and substandard practices. It also found that the company employed only one full-time, trained civil engineer to oversee the simultaneous building in the eight settlements.

Table 3 Factors affecting the likelihood of dwellings experiencing run-off and seepage

Variable	SE (*B*)	Sig. (*p*)	Exp (*B*)	95 % CI for Exp (*B*)	
				Lower	Upper
*Run-off ($n = 246$)					
Housing type					
Contractor-built	0.425	0.000	4.791	2.081	11.031
Elevation	0.025	0.003	0.927	0.882	0.974
Distance between houses					
50 cm or less	0.360	0.000	3.899	1.925	7.895
Constant[a]	0.700	0.303	0.487		
**Seepage ($n = 245$)					
Housing type					
Contractor-built	0.399	0.030	2.374	1.087	5.185
Elevation	0.026	0.000	0.893	0.849	0.939
Average building time in settlement	0.018	0.000	0.936	0.904	0.969
Constant	0.670	0.001	8.802		
***Structural ($n = 246$)					
Walls plastered or unplastered					
Unplastered	0.615	0.005	5.734	1.718	19.136
Main roof material					
Tiles	0.415	0.032	2.430	1.077	5.484
Asbestos	0.545	0.121	2.327	0.800	6.768
Roof overhangs external walls					
Roof overhangs by less than 30 cm	0.342	0.020	2.216	1.132	4.335
Average building time in settlement	0.014	0.000	0.092	0.904	0.954
Age of the household head	0.014	0.026	1.031	1.004	1.059
Constant	0.784	0.880	0.888		

* Hosmer & Lemeshow .732, Cox & Snell .170, Nagelkerke .249 (These tests show the strength of the model. The Hosmer & Lemeshow Test shows how well the model fits the data. The result should not be significant (less than 0.05). The Cox & Snell and Nagelkerke statistics approximate the R-squared values obtained in linear regression. They indicate the improvement brought about by adding the variables in question to a null model. The closer the value to 1, the greater the improvement achieved by adding the variables.)

** Hosmer & Lemeshow .108, Cox & Snell .180, Nagelkerke .263

*** Hosmer & Lemeshow .915, Cox & Snell .244, Nagelkerke .328

[a] The model included a variable on whether or not the household had undertaken measures to mitigate the risk of flooding ($p = .030$). The findings suggest an ostensibly counter-intuitive relationship between the adoption of mitigation measures and the experience of flooding, with households adopting measures more rather than less likely to experience problems (Exp(*B*) = 2.806, CI for Exp(*B*) = 1.104 and 7.136). Unfortunately, the questionnaire did not ascertain when measures were implemented, making it impossible to determine whether households adopted measures before or after the latest and/or most serious case of run-off. It is likely that instead of indicating the effectiveness of measures, the finding reflects the fact that people who experience problems are more likely to take steps to address them. Removing mitigation measures from the model has little effect on the other variables, with housing type, elevation, and distance between dwellings remaining the most influential factors

and those in low-lying areas to experience seepage, the results presented in Table 3 suggest only a weak correlation between topography and run-off and seepage. Proximity to a slope does not feature in the run-off model. Elevation appears in both models but is not a strong predictor. The likelihood of experiencing problems decreases as elevation rises, but the odds ratio (Exp(*B*) value) in both cases is close to one, suggesting only a weak relationship. Similarly, the model for structural problems suggests a relationship between socioeconomic factors such as the age of the household head and structural problems, but again the correlation is weak.

Features of design better predict whether households experience run-off, seepage, or leaks. In the case of run-off, the spacing of dwellings is influential, and run-off was substantially more likely where houses were built 50 cm or less from neighboring dwellings. Houses with unplastered walls, including those built with concrete panels, were more than five times as likely as plastered houses to experience leaks. Dwellings with tiled roofs were more likely than those with corrugated iron roofs to experience problems, as were those with small overhangs.

Dwellings with longer building times tend to show lower levels of seepage and leaks. While only a proxy measure for

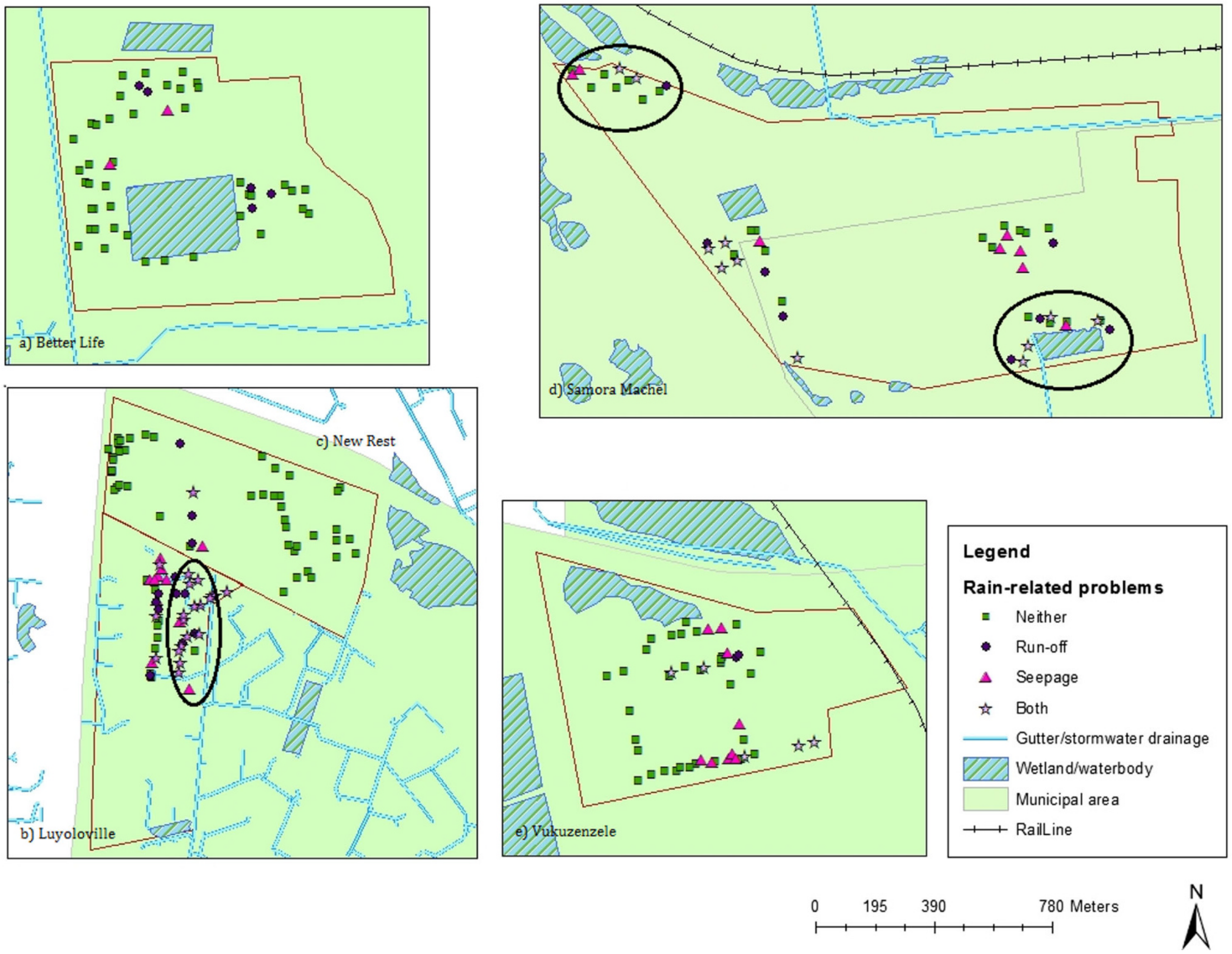

Fig. 3 Experience of run-off and seepage in selected subsidized housing settlements by proximity to water bodies in Cape Town, South Africa

the quality of construction, longer building times plausibly indicate more care in construction and greater time for concrete and other materials to cure and settle. Households in contractor-built settlements were more than four times as likely as those in PHP housing to experience run-off, and were more than twice as likely to experience seepage. This may reflect design issues. It is plausible that homeowners in PHP settlements, who construct their own dwellings with the assistance of a suitably qualified support organization, have greater input into how their dwelling is designed and built. The individualized approach may allow for more responsive designs that are better tailored to the prevailing conditions, and therefore are less flood-prone. That housing type does not appear in the model for structural problems, however, suggests that risk in both housing types is driven by specificities of design, such as the extent to which the roof overhangs the exterior walls, or whether they are plastered.

The spatial analysis supports the findings for both run-off and seepage. Figures 3a–e plot the households experiencing run-off and seepage in relation to water bodies in and around settlements, including permanent and seasonal wetlands, watercourses and retention ponds, surface gutters, or other drainage infrastructure. The dark purple dots mark households experiencing run-off, the pink triangles those experiencing seepage, and the light purple stars households experiencing both. The green squares indicate households that did not report any run-off or seepage. The findings show no obvious link between dwellings' position and their experience of rain-related problems. Although there is some evidence of an association in Samora Machel (Fig. 3d) and Luyoloville (Fig. 3b) where flooding is associated with a drainage canal running down the eastern side of the settlement, there is no evidence of a relationship in the other sites.

6 Conclusion

These findings challenge assumptions about the distribution and sources of flood risk on the Cape Flats. While it is assumed that moving people out of informal settlements and into subsidized housing solves flood risk, households continue to experience flooding, albeit often in new forms such as leaks through poorly laid roofs or badly plastered walls. This suggests an important gap in the conceptualization of risk in Cape Town, and a need to acknowledge flood risk in poor formal housing areas.

The findings also indicate that risk has a strong building component. Poorly designed and constructed dwellings serve to perpetuate risk. Layering the qualitative, quantitative, and spatial data shows that, although geography and socioeconomic issues have some influence on the likelihood of experiencing flooding, risk is most often driven by technical issues such as the way settlements are planned, how dwellings are designed, and the quality of construction. This suggests that better design and improvements in building quality would substantially reduce levels of flood risk.

The findings provide new perspectives on both urban flood risk and risk on the Cape Flats, and suggest that we need to think differently about flooding in urban South Africa and comparable settings elsewhere. They highlight a need for greater sensitivity towards the risk conditions in low-income housing. That risk is often "built-in," indicating that buildings need to be factored into the conceptualization of flood risk. As with discussions on seismic risk (Alexander 2000; Anbarci et al. 2005; Arammbepola 2007; Hosseini 2007; Smith and Petley 2009), greater awareness of design in the conceptualization and study of risk is needed. Moreover, while divorced conceptually and in practice, the study illustrates that disaster risk and housing issues are critically linked. Addressing risk effectively requires a more integrated perspective that not only looks at risk beyond informal settlements, but also connects the risk reduction and housing sectors.

Acknowledgments This article is based on a paper prepared for and presented at the 2nd Integrated Research on Disaster Risk (IRDR) Conference, "Integrated Disaster Risk Science: A Tool for Sustainability," 7–9 June 2014, Beijing International Convention Center (BICC), Beijing, China. The research was conducted with funding assistance provided by USAID.

References

Action Aid International. 2006. *Unjust waters: climate change, flooding and the protection of poor urban communities: experiences from six African countries*. London: Action Aid.

Aigbavboa, C., and W. Thwala. 2011. Housing experience of South African low-income beneficiaries. *The Built and Human Environment Review* 4: 1–13.

Alexander, D. 2000. *Confronting catastrophe: new perspectives on natural disasters*. New York: Oxford University Press.

Anbarci, N., M. Escaleras, and C. Register. 2005. Earthquake fatalities: the interaction of nature and political economy. *Journal of Public Economics* 89(9–10): 1907–1933.

Arammbepola, N.M.S.I. 2007. Ensuring safer shelter and infrastructure in urban built up areas. *Asian Disaster Management News* 13(2): 17–19.

Bahry, M. 2007. The relationship between household livelihood profile and fire and flood-related vulnerability. Honors thesis, University of Cape Town, Cape Town.

Benjamin, A. 2008. Analysing urban flood risk in low-cost settlements of George, Western Cape, South Africa: Investigating physical and social dimensions. Masters thesis, University of Cape Town, Cape Town.

Bolnick, A. 2009. Informal settlement upgrading: towards a people-centred incremental approach. Student research paper, Lund University, Lund.

Bouchard, B., A. Goncalo, M. Susienka, and K. Wilson. 2007. Improving flood risk management in informal settlements of Cape Town. Bachelors thesis, Worcester Polytechnic Institute.

Charlton, S. 2009. Housing for the nation, the city and the household: competing rationalities as a constraint to reform? *Development Southern Africa* 26(2): 301–315.

Del Mistro, R., and D. Hensher. 2009. Upgrading informal settlements in South Africa: Policy, rhetoric and what residents really value. *Housing Studies* 24(3): 333–354.

Department of Housing. 2004. *Breaking new ground: A comprehensive plan for the development of sustainable human settlements*. Pretoria (Tshwane): Government of South Africa (Department of Housing).

DiMP (Disaster Mitigation for Sustainability Program). 2005. August 2004 severe storm: Post flood assessment. Report prepared for the Prepared for Catchments, Stormwater and River Management Directorate, City of Cape Town. Cape Town: DiMP.

DiMP (Disaster Mitigation for Sustainability Program). 2007. Severe weather compound disaster: August 2006 cut-off lows and their consequences in the Southern Cape, South Africa. Report prepared for the Provincial Disaster Management Centre and the Department of Transport and Public Works. Cape Town: DiMP.

DiMP (Disaster Mitigation for Sustainability Program). 2008. Weathering the storm: participatory risk assessments for informal settlements. Cape Town: DiMP.

DiMP (Disaster Mitigation for Sustainability Program). 2009a. Report of a community risk assessment undertaken in DiMP Students in Collaboration with Urban Matters and the Philippi Youth Forum, Cape Town: DiMP.

DiMP (Disaster Mitigation for Sustainability Program). 2009b. Community risk assessment report: Never-Never and Phola Park, Philippi, Cape Town. Cape Town: DiMP.

DiMP (Disaster Mitigation for Sustainability Program). 2009c. Community risk assessment report: Sweet Home Farm. Cape Town: DiMP.

DiMP (Disaster Mitigation for Sustainability Program). 2010. Western Cape risk and development annual review (RADAR). Cape Town: Periperi Publications.

Drivdal, L. 2011a. Report on flooding in the informal settlement, "The Graveyard Pond", Philippi, Cape Town, 2010–2011. Report prepared for the Flooding in Cape Town under Climate Risk (FliCCR) project, University of Cape Town.

Drivdal, L. 2011b. Report on flooding in the informal settlement, "Egoli", in Philippi/Schaapkraal, Cape Town, 2010 and 2011. Report prepared for the Flooding in Cape Town under Climate Risk (FliCCR) project, University of Cape Town.

Field, A. 2005. *Discovering statistics using SPSS*, 2nd ed. London: Sage Publications.

Gilbert, A. 2004. Helping the poor through housing subsidies: lessons from Chile, Colombia and South Africa. *Habitat International* 28(1): 13–40.

Govender, T., J.M. Barnes, and C. Pieper. 2011. Housing conditions, sanitation and associated health risks in selected low-cost housing settlements in Cape Town, South Africa. *Habitat International* 35(2): 335–342.

Hosseini, M. 2007. On the effect of urban features on human casualty level in large and populated cities. *Asian Disaster Management News* 13(2): 9–10.

Huchzermeyer, M. 2003. Low-income housing and commodified urban segregation in South Africa. In *Ambiguous restructurings of post-apartheid Cape Town*, ed. C. Haferburg, and J. Ossenbrügge, 115–136. Münster: Lit Verlag.

Ngxubaza, V. 2010. An investigation of the low cost housing process with specific reference to the Mbashe Local Municipality. Masters thesis, Cape Peninsula University of Technology.

Pieterse, E. 2009. Post-apartheid geographies in South Africa: Why are urban divides so persistent? Paper presented at the *Interdisciplinary debates on development and cultures: Cities in development—spaces, conflicts and agency*, Leuven University, 15 December 2009.

Sakijege, T., J. Lupala, and S. Sheuya. 2012. Flooding, flood risks and coping strategies in urban informal residential areas: The case of Keko Machungwa, Dar es Salaam, Tanzania. *Jamba: Journal of Disaster Risk Studies* 4(1): 1–10. doi:10.4102/jamba.v4i1.46.

Smith, K., and D. Petley. 2009. *Environmental hazards: assessing risk and reducing disaster*, 5th ed. London and New York: Routledge.

Smith, W. 2008. Isidima: Creating dignified communities. In The state of the province report 2008, 73–85. Cape Town: Office of the Premiere.

Statistics South Africa 2011. General household survey. Nesstar online data tool. http://interactive.statssa.gov.za:8282/webview/. Accessed 26 Nov 2014.

Tomlinson, M. 2011. Managing the risk in housing delivery: local government in South Africa. *Habitat International* 35(3): 419–425.

Ziervogel, G., and Smit, W. 2009. Learning to swim: Strengthening flooding governance in the city of Cape Town. Paper presented at the 2009 Amsterdam Conference on the Human Dimensions of Global Environmental Change, Amsterdam, 2–4 December 2009.

Zweig, T. 2006. The Cape Town Community Housing Company: The registration of land process in their first eight housing developments and implications for the transfer of ownership to beneficiaries. Research report prepared for the Department of Environmental and Geographical Science, University of Cape Town.