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Case Study 19

The Romwe catchment study – the effects of land management on groundwater resources in semi-arid Zimbabwe

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This case study highlights some of the main findings from the Romwe catchment project in rural Zimbabwe. The structure of the case study follows that of the e-conference; following an opening section introducing the study findings are grouped under "landscape perspectives" and "lifescape perspectives" headings.

INTRODUCTION – THE ROMWE CATCHMENT

The Romwe catchment is a headwater catchment of the Runde river in South Eastern Zimbabwe (20° 45"S, 30° 46" E). The physical micro-catchment has an area of approximately 4.5km^2. It lies between 720 and 900m asl, and takes the form of a narrow, gently sloping valley running in an east-west direction and bounded to the North and South by steeply sloping rocky hills (see Figure 1). The geology of the catchment is crystalline basement (hard-rock), consisting of gneisses with some dolerite intrusions.

FIGURE 1
The Romwe catchment looking south-west

The catchment is home to approximately 30 families or 250 people, roughly double the population when the area was first settled in the 1950s. It contains a part of both the population and land of three "kraals" (extended families), and lies on the boundary of two wards and two traditional chieftancies. As such it is typical of almost any micro-catchment one cares to think of – with a 'physical boundary' superimposed upon a number of different social boundaries.

Land use consists of rain-fed farming on the valley floor, with fields 'owned' and managed by individuals and families. The communally owned hill-slopes are covered by miombo woodland and are used for grazing and the collection of a variety of forest products. Cattle continue to be a major repository of wealth, and are herded onto the forest slopes during the wet season and then allowed back down to the arable fields during the dry season.

A relatively recent development (starting in the 1980s) has been the construction of hand dug wells used for the irrigation of small vegetable plots. These were complemented in 1991 by a 'collector well' - a large diameter well with lateral boreholes drilled at its base - equipped with two hand pumps and used for both domestic water supply and irrigation of a 0.4ha irrigated garden with plots for 40 families. This type of mixed use water point has been dubbed a 'productive water point' to distinguish it from those used exclusively for domestic purposes. The collector well was provided by a DFID funded research project, carried out by the UK

Institute of Hydrology in partnership with the British Geological Survey and Zimbabwe Department of Research and Specialist Services.

Since this initial project, the Romwe catchment has been subject to an intensive programme of multidisciplinary participatory research. This has focussed on the relationship between climate, land management and water resources (mainly groundwater), and the role that water resources play in peoples farming systems and livelihoods. The first author was resident in the catchment between 1995 and 1999 and completed his PhD based on research there. Current research continues under the leadership of the University of Zimbabwe's Institute of Environmental Studies (IES) http://www.uz.ac.zw/ies/mcm/index.html

Landscape perspectives – *"Land use practices are assumed to have important positive and negative impacts on both the availability and quality of water resources in small to medium mixed rural watersheds"*

While the study has identified important ways in which land use does affect groundwater availability, it has highlighted two crucial parameters 'external' to the farming system that drive the system and limit the possible range of land management/groundwater interactions. These are climate and geology.

Climate: Semi-arid climates are typically described using words such as 'extreme' and 'unpredictable'. This is often based on an analysis of inter-annual variability of rainfall, which is indeed high. Annual rainfall in the Romwe catchment since 1991 has ranged from an estimate of less than 300 mm during the 1991/92 drought to more than 1,100mm in 1996/97. However, more important than the inter-annual variability is the cumulative effect over a number of years. In Zimbabwe and much of Southern Africa annual rainfall has been observed since the start of the century to follow a pattern in which roughly 9 years of generally "above average" rainfall is followed by nine years of generally "below average" rainfall. The observed effect of this on ground water levels is striking, with levels fluctuating between two extremes representing dry and wet periods respectively. The groundwater buffers or smoothes the inter-annual variability and reflects the longer term trend.

This smoothing effect is also mirrored in biomass production. In wetter periods there is good growth of grass and browse, with the result that even when a dry year occurs (as they often do) the effects are buffered, with livestock able to eat the previous years grass, and trees still able to produce leaves and fruits due to the generally high water table. Conversely, during drier periods exposure to risk becomes ever higher as groundwater levels recede, and grass and shrubs dry up. Zimbabwe's devastating drought of 1991/92 occurred when a long period of low rainfall (most of the 1980s) was capped by a total failure in that year. A reflection of the impact of this periodicity of rainfall on humans is that cattle numbers are seen to closely follow the long term rainfall trend, with the communal herd building during wet periods and then collapsing during dry.

Geology: Crystalline basement areas generally consist of shallow soils overlying more or less impervious rocks. The result is that the majority of 'groundwater' exists in the weathered zone within 30-40m of the surface – during wet periods the water table of much of the catchment is within 2-3 metres of the surface. The most important implication is that water is almost always within the root zone of vegetation, particularly large trees, and is therefore always being used. There is no deep untapped reservoir of groundwater, and indeed the entire concept of 'groundwater' needs to be treated with great care.

Effect of land management on groundwater: The relationship between land management and groundwater in this environment is interesting, complex, and sometimes counterintuitive. Land management has only a marginal effect – the main driver for groundwater availability is climatic. Having said this, land management decisions do affect groundwater availability, and two aspect in particular are worthy of consideration.

Valley bottom deforestation – The deforestation of the valley bottom by early settlers has almost certainly greatly increased the available groundwater resource. Each year, measurements show that almost all the wet season 'recharge' is subsequently lost to evaporation during the dry season. The only year in which there was a significant year on year rise in water table was in 1995/96 when heavy rains made the water table rise approximately 3m from its 'dry period' level to a new 'wet period' level where it has remained to date. Modelling suggests that if the valley bottom were to be reforested the groundwater would be severely depleted, and that even the development of valley bottom wood lots could have significant effects on available water.

In field soil and water conservation – Given the non-linear relationship between recharge and rainfall, in-field structures can have an important effect on groundwater recharge. Put simply annual rainfall of less than 400 mm causes little or no recharge, while above 800 mm (particularly with large intense events) causes significant recharge. Between these two limits, recharge will only take place in areas where localised runoff ponds, for example, in small dams, behind dead-level contour bunds, and in ditches. These structures have a positive effect on groundwater recharge. In contrast, structures such as tied ridges that reduce in-field redistribution of runoff and improve crop yields may sharply reduce recharge.

The implications of these two findings are that there are real trade-offs to be made between forestry and other land use activities, and between management of fields to maximise soil moisture for rain-fed crops or groundwater recharge (for irrigated crops).

Lifescape perspectives – *"The benefits of improved land management, or the negative consequences of land use practices on water resources, might not only be felt by resource users who cause them, but also by others who live downstream or make use of the affected resources"*

Again, as for 'landscape perspectives' the physical properties of crystalline basement control how the effects of land management propagate themselves to resource users 'downstream'.

In general, groundwater in crystalline basement is a highly localised resource, and needs to be developed and managed at a level that fits well with existing social and institutional structures. This is because the crystalline basement 'aquifer' is, even at the micro-catchment scale, a highly discontinuous series of 'micro-aquifers'. Different weathering profiles and discontinuities such as dykes prevent groundwater movement over anything but short distances. Instead, having percolated through the unsaturated zone, the groundwater pools in localised areas of deeper weathering and fracture zones. There are several such zones within the Romwe catchment, each associated with increased groundwater development for small scale irrigation.

The overall implication of the work at the Romwe catchment is that groundwater in this environment is a resource best managed at the micro-catchment scale , with small groups making decisions about how they feel their groundwater can best be used (forestry vs. grazing for example), or indeed whether they wish to focus on groundwater (for example for irrigation purposes) or on improving their rainfed crops (through infield moisture conservation). In either case, the impact on 'downstream users' outside the particular micro-catchment will be minimal.

The following documents provide more information on the Romwe catchment project and productive water point development:

Lovell, C.J., (2000) *Productive water points in dryland areas: guidelines on integrated planning for rural water supply*, Intermediate Technology Publications, London, UK

Moriarty, P.B. & Lovell, C.J., (1997) *Groundwater resource development in the context of farming systems intensification and changing rainfall regimes: A case study from south-east Zimbabwe*, AgREN Network Paper No. 81b, ODI London

Lovell, C.J., Butterworth, J.A., Moriarty, P.B., et al., (1998) *The Romwe Catchment Study, Zimbabwe – Final Report*, IH Report DFID 98/3, Institute of Hydrology, Wallingford, UK