Drylands Learning and Capacity Building Initiative for Improved Policy and Practice in the Horn of Africa

Good practice principles on planning for water and irrigated crop agriculture in the drylands of the Horn of Africa

DLCI, May 2015[1]

Introduction

The Horn of Africa (HoA) needs to use its limited water sources more wisely. The drylands of the HoA are typically water-stressed areas: characterised by low and variable rainfall, high ambient temperatures and evaporation rates, and surface water resources that are highly seasonal. Substantial groundwater resources lie beneath the drylands, although they are often of poor quality and vary considerably in depth. These resources are also to a large extent finite—ancient water sources that are not being replenished. Some dryland areas benefit from perennial rivers passing through them from moister highlands, but these rivers are increasingly diminished through poorly regulated upstream abstractions, often linked to irrigation schemes.[2] Upstream groundwater resources are also being rapidly depleted.

Over large areas of the region groundwater is the only source of water for the largely pastoral communities. Access to water is a basic human right, but one that has been largely neglected by governments in the Horn. Humanitarian relief agencies, NGOs and church organisations, have focused on developing supplementary water sources in the form of engineered boreholes, small dams and water pans—many of which have been managed in an unsustainable way. Irrigation is now being increasingly promoted in these drylands in an attempt to meet national and local food security challenges through crop agriculture. It is important that these interventions recognise the problem of increasing water deficit and the lessons from failed irrigation investments in the past. As the citizens of dryland areas are often the most vulnerable and food insecure in the region, investments should not undermine their existing pastoral livelihoods by taking away critical land and water resources.

In the drylands of the HoA the full potential of livestock production to national economies remains unexploited, yet governments in the region continue to give precedence to investments in crop agriculture as the main solution to food security—agriculture that will depend on irrigation.[3] This prioritisation ignores all-important water resource availability issues; as well as the extensive exploitation costs and the available evidence of the environmental impact of irrigation. A lack of documentation for sharing the impacts of failures of irrigation in the

[1] Written by Sean Avery, DLCI consultant and Vanessa Tilstone DLCI, based on a series of studies on water and irrigation carried out by REGLAP and DLCI since 2012. Edited by Helen de Jode. Input was gratefully received from Omeno Suji and Roger White.
[2] See Lower Omo case study, Avery (2013).
[3] Benkhe, R. & Kerven, C. (2013). Counting the costs: replacing pastoralism with irrigated agriculture in the Awash Valley, north-eastern Ethiopia. http://pubs.iied.org/10035IIED.html

arid and semi-arid lands (ASALs) is severely limiting the ability of stakeholders to learn from their mistakes, and for evidence-based advocacy. There is an urgent need for more comprehensive evidence-based guidance.

The continued expansion of irrigation schemes in the HoA needs to be based on comprehensive assessments of water and land availability, as well as independent environmental and social impact assessments, cost-benefit analysis, and comparisons with other potential investments that properly take into account existing ecosystem service provision. Lessons from the past should be incorporated into planning, particularly issues such as poor consultation and ownership by local people; poor design and quality of infrastructure; lack of local capacity to construct, manage and maintain water and irrigation schemes; as well as poor marketing potential resulting from by insecurity and inadequate transport infrastructure.

Based on existing studies and recent reviews by DLCI/REGLAP and FAO, this document provides some principles and lessons learnt so far on water supply and crop agriculture in the drylands of the HoA, with a particular focus on Kenya.

General observations

1. Externally engineered water supply and irrigation interventions are too often poorly conceived and poorly constructed, and are prone to early breakdown, leading to disillusionment and conflict within the beneficiary communities. A contributing factor is a lack of community training on management and maintenance, a process that requires persistence and regular follow-up. Water supply and irrigation interventions are often the result of donor programmes that encourage rapid infrastructure development but insufficient community participation. Donor-funded water supply interventions also often require communities to collect user fees, a requirement that conflicts with traditional expectations that water resources are free.
2. Returns on investment in irrigation in the drylands are often poor, and less than the same investment that would be achieved in other livelihoods, especially livestock production. This is particularly true when the loss of biodiversity and the full impacts on water resources are considered. Food security considerations need to consider the productive potential of dryland areas for these different forms of agriculture, and take account of the opportunities for trade with high crop potential areas.
3. Irrigation schemes in the ASALs are usually planned without proper assessment of the marketing potential and constraints or plans for improvement. ASAL areas are generally characterised by poor infrastructure, undeveloped markets, lack of marketing capacity and negotiating skills, financing and producer organisation, all of which needs to be addressed as part of irrigation promotion.
4. The irrigation potential of the drylands of the HoA is limited by the scarcity and quality of its water. Detailed hydro-meteorological data is often inadequate or inaccessible for proper planning—making over-estimates likely—and there is often insufficient attention paid to water quality and soil types.
5. Most irrigation schemes found in the ASALs of Kenya are subsistence-level farms that are dependent on, and motivated by, outside financial assistance. A recent FAO study concluded that irrigation projects in Turkana

County in Kenya require subsidies of about 90%.[4] Irrigation scheme developments in the drylands also often lead to an influx of outsiders with adverse social impacts.

6. Irrigation development planners invariably select the most productive areas of land. These are inevitably adjacent to valuable water sources, and often occupy dry season grazing areas valued by pastoral populations, thereby undermining their mobility strategies, and sometimes causing conflict.

Good practice principles for irrigated crop agriculture

These good practice principles aim to provide general guidance for policy makers and development agents proposing to establish irrigation schemes for crop agriculture in the HoA. The intention is to promote discussion and learning amongst everyone involved in irrigation in the drylands. It is hoped the guidance will encourage more evaluations and impact assessments, and the documentation of good practice, so that these principles can be further elaborated. DLCI's purpose is to raise awareness and build capacity in the drylands of the HoA. Comments and suggestions on this document are welcome at our email given below. The good practice principles cover: initial feasibility assessments; agronomic considerations in drylands irrigation; technological considerations for irrigation in the HoA; and monitoring and implementation issues.

1. Feasibility Assessments for Irrigated Dryland Agriculture

In determining whether irrigation is a feasible option in the drylands of the HoA, it is important to undertake assessments that look at the hydrological implications, the legal/regulatory framework, the environmental and social impacts, as well the economic/financial viability of interventions. Impact and social assessments should be robust and carried out by independent, experienced and accredited professionals with full consultations with the communities affected and other stakeholders. Assessments should seek to learn from past challenges and should ensure outcomes are appropriately communicated to all those involved in water and irrigation projects; including government, development partners and citizens that benefit from the schemes or will be affected by the use of land and water resources. Design documents should be made publicly available, and retained to facilitate proper evaluation and impact assessment.

Water resource issues

Water in the HoA is an essential and yet limited resource, both in terms of quantity and quality, and needs to be carefully considered during irrigation expansion in the drylands. Comprehensive water availability and quality assessments should be undertaken before planning any irrigation scheme. Assessments should adequately consider the high evaporation rates in the drylands given high solar radiation and temperatures. Climate, rainfall and surface water runoff data is essential to scheme planning. Unfortunately hydrometric stations are very challenging to operate in the drylands, due to remoteness, theft, climate, and other factors. As a result, such

[4] OCRA study for FAO of irrigation prospects in Turkana County, 2013.

hydrometric data is often non-existent. Specialist hydrologist skills are required in making competent assessments in the absence of data. Wherever possible, measurement stations should be installed to verify data assumptions before commitments are made to invest in schemes. Hydrological assessments need to consider:

Rivers

a. Water and irrigation planners must recognise the importance of protecting riparian zones in order to limit erosion and damage from floods.
b. Planners must recognise that dryland rivers often naturally meander within broad flood plains, and that permanent water abstraction intakes are prone to be being left literally 'high and dry'.[5]
c. Where river gauging stations exist, the data is often intermittent, and the calibration of such stations is rarely checked. River gauging of seasonal rivers is non-existent. Hydrological analysis requires experience, and often necessitates data infilling and hydrological modelling methodology, for which specialist skills are required.
d. Rivers that criss-cross the drylands are often mobile, and often have high silt and bed load, which adds to the operation and maintenance challenges that should be considered in the costing of any schemes.
e. Irrigation water abstraction assessments need to recognise that rivers provide ecosystem and other services that must be sustained. Downstream, rivers need sufficient water remaining to satisfy ecological needs and the needs of downstream users. It should also be remembered that rivers recharge riverbank aquifers, and that these aquifers sustain riparian forests. If the aquifers are not replenished, serious environmental consequences ensue.

Aquifers

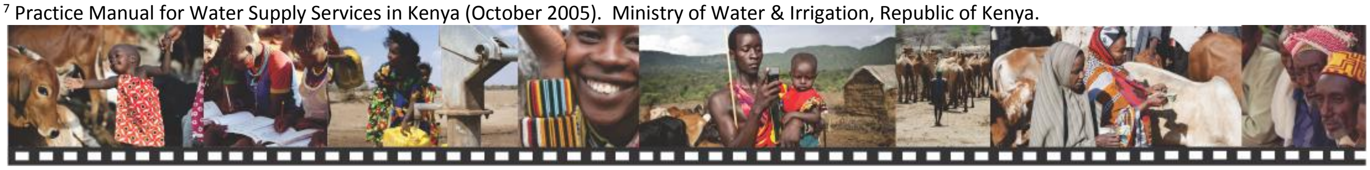
a. Groundwater aquifer monitoring systems are largely non-existent. Competent groundwater exploration and exploitation requires specialist hydro-geological skills, experience and equipment. Remote sensing technology has added to the suite of tools available to the professional hydro-geologist. However these do not remove the need for ground verification through fieldwork and competently managed drilling and test pumping programmes.[6]
b. As rainfall is low in the drylands, groundwater aquifer recharge is also low. The sustainable yield of dryland aquifers is limited by the recharge, which is a function of rainfall. There are recent examples of groundwater studies that hugely over-estimated recharge rates and yields causing unrealistic expectations that now have to be managed and corrected.6

Water demand assessments must also consider the requirements for all other domestic, institutional, livestock, irrigation, fisheries, and commercial water users. When determining water and irrigation water demands, reference should be made to local design manuals, for example Kenya's Ministry of Water and Irrigation's water services practice manual.[7]

[5] A good example in Kenya is the Hola Irrigation Scheme. See the engineering services report on the Hola Irrigation Scheme for Kenya's National Irrigation Board in 2004.

[6] See Avery, S. (2014). The Turkana Aquifer discoveries and development proposals. DLCI discussion brief. http://www.disasterriskreduction.net/fileadmin/user_upload/drought/docs/Final_discussion%20paper_Turkana%20aquifer.pdf

[7] Practice Manual for Water Supply Services in Kenya (October 2005). Ministry of Water & Irrigation, Republic of Kenya.



Legal/regulatory issues

Planning for irrigation requires an assessment of the statutory legal framework as well as the customary legal framework. Specialist skills are needed for both.

In Kenya, the Water Allocation Guidelines issued under Kenya's Water Act[8] stipulate the proportion of the river flow or the aquifer that is reserved for ecological needs, and thus cannot be abstracted. This 'reserve' should be considered in all water and irrigation design, and must be monitored and enforced rigorously. Aquifer systems should not be continuously pumped, and in this regard, solar-based systems are favourable as aquifer rest periods are in effect naturally enforced. In Kenya riparian zones are also protected under the provisions of the Water Act and no cultivation is allowed. Any interference with these areas by water and irrigation interventions is illegal unless licensed under Kenya's Water Act.

Unfortunately institutional capacity of public institutions in Kenya are often not adequate to enforce statutory legal requirements, and is often in a state of flux. For example, the new draft irrigation policy is introducing new institutions even though existing institutions have not been properly managed or supported.

Dryland areas are rich ecosystems that are generally poorly understood and often viewed as unused wastelands, even though they may support livelihoods and ecosystems that numerous people are dependent on, including people from other counties and countries. Until such time as those people who depend on dryland resources have clearer tenure and use rights, any resource use change will need to be agreed with customary users. Participatory land use planning is critical to guide water, irrigation and other developments, as it considers the cross-county and cross-border nature of pastoral livelihoods, wildlife migration, the protection of strategic dry season grazing areas, as well as livestock migration and marketing routes.

Environmental issues

An environmental and social impact assessment (ESIA) is a mandatory requirement for any water or irrigation project in Kenya.[9] The ESIA provides an environmental and social management plan (ESMP). Reference can be made to guidelines and requirements periodically issued by the National Environment Management Authority (NEMA) in accordance with the Environmental Management and Co-ordination Act (EMCA). The guidelines draw from international best practice and are widely applicable. The ESIA studies should be independent and objective and should only be undertaken by competent environmental experts experienced in the drylands.[10] The environmental impacts arising from water supply and irrigation activities that need to be foreseen and managed include the following:

[8] The Water Act (No.8 of 2002), Republic of Kenya.

[9] Environmental (Impact Assessment and Audit) Regulations, 2003, issued under the Environmental Management and Coordination Act (No.8 of 1999), Republic of Kenya.

[10] Too often these documents are next to useless as they are "cut and pasted" from text books or irrelevant studies in other climatic zones.

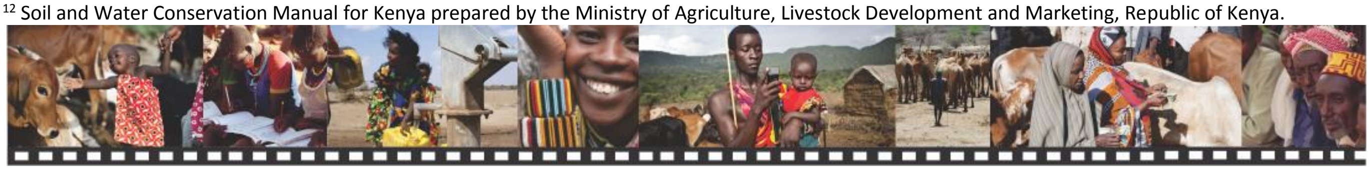
a. Land degradation resulting from land clearance, removal of indigenous vegetation and interference with natural drainage paths.
b. Potential upsurge of water-borne diseases from consumption of raw irrigation water, and canals providing breeding conditions for disease vectors such as mosquitoes and snails.
c. Possible fertiliser and pesticide pollution reaching the groundwater table and watercourses.
d. Potential for upsurge/introduction of new crop pests and diseases. The introduction of new crop species changes local habitat dynamics, and may attract different pests, or introduce new ones, thereby altering the existing habitat equilibrium.
e. Clogging by invasive plant species including waterweeds and *Prosopis juliflora*. Appropriate prevention and management measures should be considered - see Ethiopia's experiences in *Prosopis juliflora* management.[11]
f. Downstream flows are reduced through abstractions, with many environmental consequences.
g. Salinization of soils is common in arid and semi-arid lands where rainfall is insufficient to leach soluble salts down through the soil profile, and can lead to loss of soil fertility. Irrigation can exacerbate the problem unless there is adequate good quality flushing water and adequate drainage to carry away the flushed salts.
h. Functional ecosystems provide valuable ecosystem services that should be integrated within appropriate planning. For instance, functional riparian forests should not be cleared to make way for irrigation projects.
i. Whereas erosion is a natural process, accelerated erosion is a consequence of human activity that needs to be managed through appropriate land husbandry.[12] Poor management of water causes excessive runoff and erosion, and less water infiltrates. To enhance existing production, investments are required to maximise water infiltration and the water-holding capacity of soils. Soil and water conservation manuals deal extensively with this topic.[12]
j. Competition with livestock and wildlife: While livestock integrate well with natural dryland fauna and flora, irrigation schemes produce crops that can attract wildlife and create human/wildlife conflict zones. These conflicts often lead to destruction of indigenous wildlife, some being endangered species. Encroachment into wildlife habitats may also create conflict through interference with migration corridors.

Social issues

Appropriately qualified experts should assess the social impacts of irrigation as part of the overall assessment process. Social impacts should be conducted together with the environmental impact assessment. Where impacts are potentially negative, mitigation measures should be put in place before implementation.

Irrigation in the drylands is likely to be carried out on prime land that is essential for extensive livestock production systems to function. Thus, irrigation projects can undermine the livelihoods of numerous people (often some of the most vulnerable) including people from neighbouring counties and countries, and can lead to vulnerability during drought and conflict.

[11] Farm Africa's case study on *Prosopis* management for Afar region of Ethiopia.
[12] Soil and Water Conservation Manual for Kenya prepared by the Ministry of Agriculture, Livestock Development and Marketing, Republic of Kenya.



Assessments should be carried out in conjunction with communities likely to be affected by the schemes, both directly and indirectly, and also the communities and local authorities expected to sustain the schemes in the long term. Assessments should recognise their different livelihood strategies, identify strategic resources and understand their different water demands. Plans should then ensure access for people, livestock and wildlife to riverbanks[13] that they are dependent on to avoid conflict. Plans should also recognise that riverbanks are within the riparian zone[14] and thus should be protected.

When determining whether communities are interested in being part of an irrigation scheme, communities, especially those that that will be new to crop production, will require accurate information to assess the viability and sustainability of the schemes as part of the assessment and planning process. Vulnerable HoA communities may accept any support offered to them, especially if they believe that no other support will be forthcoming if they reject crop agriculture.

Economic/financial viability

Many irrigation schemes have proved to financially unsustainable. Expert economic analysis/cost-benefit analysis is important. Returns on investment in irrigation also need to be compared with the same investment in other livelihoods, especially livestock production. The concept of virtual water (the 'hidden' volume of water needed to produce a product) needs to be kept in mind, as the water footprint of irrigated agriculture is very high in the drylands. The consequential cost of biodiversity loss and impact on water resources and downstream users should also be included in such comparisons. Methodologies such as total economic valuation of pastoralism should be employed.[15] When compared to domestic and livestock water requirements, the requirements for extensive cash crop production in the drylands are enormous For example, it is estimated that the Kuraz irrigation scheme in South Omo, Ethiopia, will require a water quantity that alone is numerically equal to 25% of Kenya's entire renewable surface water resource.[16]

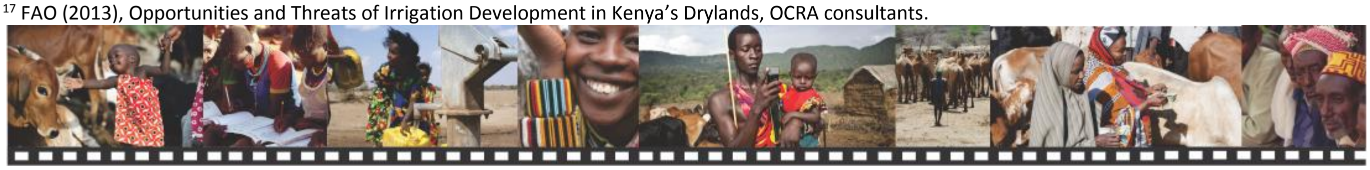
Dryland areas are often remote with poor roads and communications limiting potential for commercialisation, and limiting the viability of schemes. Perishability of products should be carefully considered given the remote and hot environments and poor infrastructure.

Irrigation infrastructure in the drylands can have a limited life due to frequent flash floods, often less than five years instead of the normal 30-year lifespan.[17] Thus reconstruction should be factored into cost-benefit analyses.

2. Agronomic considerations for drylands irrigation

A full assessment of the agricultural potential of the area needs to be conducted by a suitably qualified agronomist to assess the suitability of the proposed crops. Considerations include land capability, soil types and local growing

[13] Vulnerable people, especially women may rely on grass collection during times of stress e.g. in Mandera.
[14] In Kenya cultivation is illegal in the area from the bank that is the width of the river to a maximum of 30m, Water Act of 2002, Kenya.
[15] Benkhe R. & Carol Kerven - IIED Working Paper No.14, dated March 2013.
[16] Avery (2014), The Turkana Aquifer discoveries and development proposals, DLCI.
[17] FAO (2013), Opportunities and Threats of Irrigation Development in Kenya's Drylands, OCRA consultants.



conditions. Crop water requirements, soil infiltration/leaching rates, topography and local climate data will all be important. The assessment will need to determine the overall production strategy, including pest and weed management.

Crop water requirements can be computed using FAO's freely available software CROPWAT[18] and climate database CLIMWAT.[19] Manual computations can be made through reference to FAO training manuals.[20] A recent study in Turkana County in Northern Kenya reported that whilst maize and sorghum occupied 75% and 24% of the irrigated crop area, sorghum produced 40% more product per hectare than maize.[21] For future cropping, this FAO study recommended maize and sorghum in higher proportions, supplemented by cowpeas, kale, mangoes and bananas. In Tana River District of Kenya, the FAO study recommended a typical cropping pattern that included maize, sorghum, green grams and rice.[22]

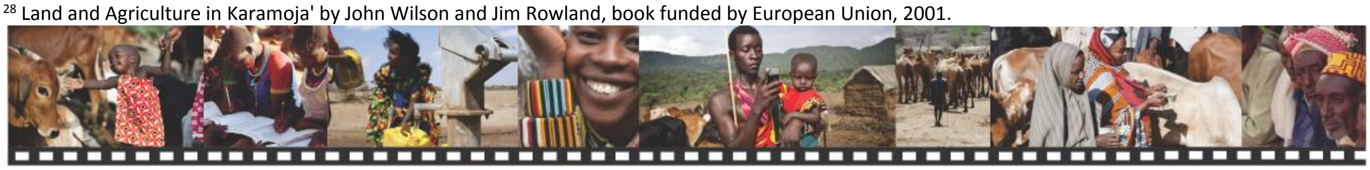
As well as water, irrigated crops require suitable climatic and soil conditions. Climate considerations include sunshine, temperature, humidity and wind speed—data for which is obtained from long-term meteorological stations.

In Kenya, extensive soil mapping has been undertaken to identify the suitability of soil conditions,[23] and for much of Kenya suitable crops can be selected through reference to the numerous studies, making choices for which there are ready markets.[24] Similar data also exists throughout the HoA. Kenya's Farm Management Handbook[25] is a valuable resource, but it does not specifically cover the northern areas of Kenya, and its scope could be usefully revised and expanded in line with the new irrigation expansion goals.

Crop production guidelines have been produced in Kenya for some dryland crops[26], but these rely on the application of chemical fertilisers, herbicides and pesticides. Careless application of chemicals may destroy beneficial insects and lead to a spiralling cycle of ever-increasing and costly chemical dependence. Thus traditional cropping methods should not be overlooked.[27] These methods exploit crucial traditional knowledge on crop rotation, timely planting, clean weeding, crop hygiene, use of resistant crop varieties, and good quality seeds. They also recognise the conditions under which pests will flourish.

While crop trials have been conducted in the drylands, for instance in Karamoja,[28] further study is still needed, preferably with the full involvement of the farmers themselves. Rather than favouring exotic crops, indigenous

[18] http://www.fao.org/nr/water/infores_databases_cropwat.html
[19] http://www.fao.org/nr/water/infores_databases_climwat.html
[20] Irrigation Water Management Training Manual No.3, Irrigation Water Needs, produced by ILRI and FAO Land and Water Development Division, 1986.
[21] OCRA study for FAO of irrigation prospects in Turkana County, 2013.
[22] OCRA study for FAO for irrigation prospects for Tana River County, 2014.
[23] Exploratory Soil Map and Agro-Climatic Map of Kenya, Kenya Soil Survey, 1982.
[24] As an example, see the studies commissioned by FAO - Ocra (2013) and Ocra (2014); also see Wilson & Rowland (2001).
[25] Farm Management Handbook of Kenya, Ministry of Agriculture, Kenya, 1982.
[26] Production guidelines for some dryland crops, KARI leaflet, KARI-Katumani, Kenya.
[27] Land and Agriculture in Karamoja by John Wilson and Jim Rowland, book funded by European Union, 2001.
[28] Land and Agriculture in Karamoja' by John Wilson and Jim Rowland, book funded by European Union, 2001.



species should be used where possible, and those for which good quality seeds are readily available. Salt tolerant crops also need to be investigated so that poor quality water might also be utilised.

Where a scheme is intended to engage the local farming community, **an assessment of extension/technical support** is also critical, particularly for people new to cropping or irrigation technology:

a. There is need to invest considerable time and resources in extension, covering issues such as: land selection, preparation; all aspects of planting (seedbed preparation, soil management, water conservation/irrigation techniques, seed planting and pest control before germination); crop management during growth including weeding; and training on harvesting techniques, hay making and storage, distribution and marketing.
b. In many dryland areas in the HoA, extension services are limited (often with extension agents based in urban centres with limited transportation to reach communities, e.g. in Turkana[29] the extension agents said they only visit when other organisations transported them. Increasingly, extension services are not provided free, and therefore costs of extension have to be built into projects and the cost-benefit analysis.
c. The availability and quality of seed should be checked before engaging farmers in irrigation schemes, with seed availability for the future verified and promoted to enable replacement in the case of flood or pest damage.
d. Dryland areas have poorer education levels and communication infrastructure than other areas, a key factor in designing extension services. Multiple ethnic groups and languages may be present in one administrative area complicating mass communication. Communication methods need to take into account social and cultural barriers to information access including access for women.[30]

As well as extension support, an agronomic assessment will need to consider a number of **other socio/economic factors** that arise from altering local livelihoods:

a. Where local communities have requested irrigation support, compensation should be provided to those who will be affected by the loss of land and water resources.
b. Inputs should be provided to communities on credit or partial credit to avoid dependency, to ensure ownership and to prevent undermining private sector provision.
c. Mixed crop, and mixed crop and livestock production systems should be considered, especially for subsistence/small-scale agriculture. Greater diversity spreads risk, and the potential for drought mitigation and market variability is greater.
d. Short-term interventions that do not provide adequate capacity building for sustainability should not be undertaken, as they waste funding, raise expectations and lead to disillusionment.

[29] DLCI Turkana irrigation scheme visit report, September 2014.

[30] KRDP (2012). Strengthening information dissemination at community level: a disaster risk reduction and early warning information perspective http://www.dlci-hoa.org/download/strengthening-information-dissemination-at-community-level-a-disaster-risk-reduction-and-early-warning-information-perspective/?wpdmdl=3763

e. In some pastoral cultures, crop production is seen as a low status occupation. Thus, ethnic groups from other areas are imported as daily labourers, often creating tensions with local populations. The impact of imported labour is being seen in many areas being opened up for crop production.
f. The move from pastoralism to crop production can undermine men's traditional roles and status within the community, and if not managed carefully, can lead to frustration, drug and alcohol abuse and increase in gender-based violence.
g. In many areas women take on much of the labour in crop production, increasing their burdens often with little control over the use of produce or its profit.
h. Farmers should be selected in accordance with the objectives of the irrigation scheme. Those who have lost their livestock, and are not able or interested in returning to the pastoral system, and also have the interest and potential skills to engage in crop agriculture, should be prioritised. People targeted should have sufficient labour and support to learn the necessary skills and techniques, including marketing skills. Selection on the basis of land or pump ownership will usually exclude the poor and women. Opportunities may be required for the inclusion of disadvantaged community members via credit or loan schemes.

3. Technology issues for irrigation schemes in the HoA

Designing an efficient irrigation scheme requires a considerable level of skill. As well as formal qualifications, irrigation designers need successful practical experience of working within the environmental and social context of the drylands in the HoA. Technical issues include:

a. New technologies should be carefully assessed for appropriateness in the unique physical, economic and social environment in the drylands, and should be affordable without dependence on donor subsidies. New technologies, particularly those that have only been tested in non-dryland areas, should be introduced with considerable caution. Feasibility assessments should be made by experts experienced in the drylands to assess their suitability, and should be carefully piloted and reviewed. For example, plastic-covered greenhouses and shade-nets have a short lifespan when exposed to the intense sun, heat, strong winds and sand damage characteristic of drylands, and the replacement costs are often beyond the financial resources of small-scale subsistence farmers. Too often these technologies are imported and subsidised by NGOs to then be abandoned when they no longer function.
b. Large-scale borehole-based irrigation schemes are extremely expensive. In addition to high water source development costs, operation and maintenance and pumping costs are high given the huge water requirements of dryland agriculture. A small irrigated plot, using a hand-pump or treadle-pump, is cheaper.
c. Engineering interventions to control river meandering are possible but very costly and their effectiveness uncertain. Rather than permanent intake structures, portable pontoon-based intakes have in some cases been adopted, but these are prone to being lost downstream in floods.
d. Groundwater resources in dryland areas are often too saline for crop irrigation, or risk becoming saline if over-pumped. Desalination technology is available, but is costly, especially when large quantities of water are involved.

e. Dryland rivers are generally seasonal and extensive storage provision is required to sustain water and irrigation schemes through the often-extended dry periods. The topography of dryland areas is often flat, and as such, these areas are often not well suited to efficient water storage in reservoirs formed by dams, with high evaporation losses ensuing. If the rivers carry high sediment bed loads, the reservoir storage capacity needs to be sufficient to accommodate sediment deposition. These design challenges add to the significant cost and limit the lifespan of the storage reservoirs.

f. Proper flood management measures should be included in scheme design. For instance, dam structures and irrigation intakes frequently get washed away, and the off-take canals can act as conduits conveying destructive flood waters into the irrigation scheme crop areas.

g. Given the scarcity of water in the drylands, water-saving irrigation technologies should be used where possible, although they need to be properly assessed for use in dryland contexts. For example, drip irrigation systems can achieve 90% overall efficiency, compared to flood irrigation systems that are around 40%, but with the very high evaporation rates and mineralisation of water in drylands, drip irrigation systems are vulnerable to orifice clogging by evaporated salts—the water needs to be filtered and pipes regularly flushed to prevent blocking with sediment.[31] The drip pipes are vulnerable to physical damage through trampling, being chewed by rodents, through exposure to solar radiation and fire.

h. Techniques that aim to capture the available rainfall by controlling its runoff should be considered. Examples include water retention pits, ditches, and basins, with water being directed through terraces, contour ridges and bunds. For domestic and livestock water use, rainfall is commonly harvested from roofs and rock catchments into tanks, and can also be stored in pans and behind small earth and sand dams. In-field water retention methods include tied contour-ridging methods, for which benefits were demonstrated at *Katumani* in Kenya, but whose performance was variable at other locations.[32] These tied contour-ridging methods are labour intensive, and success depends on soil characteristics, but such methods are worth pursuing. Hardpan zones can develop in arid land farms, and farming methods can be adapted to break up these layers.[33]

4. Implementation and monitoring

Irrigation schemes require effective management, operation and maintenance if they are to function effectively. The operation and maintenance of a scheme needs to be factored into the planning and design stage. Long-term impacts should be monitored throughout implementation for lesson learning and course correction. Across the

[31] See Avery, Sean (2014). Water Development and Irrigation in Karamoja, Uganda. A review prepared for DanChurchAid / REGLAP / EU. http://www.disasterriskreduction.net/fileadmin/user_upload/drought/docs/REPORT%20DCA%20KARAMOJA%20FINAL_March%202014.pdf

[32] See Case Study in Kenya's Soil and Water Conservation Manual.

[33] Managing soil hardpan, KARI leaflet dated 2012, KARI-Katumani, Kenya.

HoA a lack of monitoring and supervision, has often resulted in poor quality of water infrastructure, requiring early reconstruction and replacement, adding to the costs of investment. A monitoring system should consider:

a. Arid land soils are prone to salinization, and to prevent this, the associated scheme drainage works must be fully maintained to remain operational. The high siltation load of dryland rivers leads to silt deposits that clog up irrigation infrastructure. The suspended sediment in the water reduces the lifespan of pumping systems and pipes through erosion. Invasive alien plants like *Prosopis juliflora* will quickly infest and clog irrigation and drainage canals. Thus irrigation infrastructure must be cleared regularly to remove sediment and invasive plants, and maintenance costs must also be factored into O&M plans and cost-benefit analyses.
b. Flood and drought early warning systems are helpful, but by no means sufficient, to prevent loss of crops, seeds, assets and lives and environmental damage. Early Warning Systems should be developed so that they are trusted and well understood by communities, and alerts should reach them in a timely manner. Rainfall forecasts are familiar to communities, but floods are a different matter. Dryland rivers can rise and fall in hours, and often the causative rainfall occurs far away where local people cannot see it. Thus ensuring communities understand the value and reliability of early warning systems is critical. Plus, often schemes susceptible to flood damage are illegally established within the riparian zone, which should be adequately understood, and discouraged. Accessible early warning and market information at local level also enhances producers' ability to judge the best and most important time to sell.
c. In addition to the comprehensive environmental impact assessment undertaken at the outset, regular participatory environmental audits should be carried out to monitor any changes in the various environmental variables and ensure corrective measures. In Kenya these are mandatory, and should be carried out annually in order to capture the full annual climate cycle.
d. Clear mechanisms should also be put in place to promote accountability and corruption monitoring. Linkages may be possible with existing accountability mechanisms in the region e.g. Transparency International – Kenya's joint accountability initiative ('*Uwajibikaji Pamoja*') and social auditing programs. Active involvement in such schemes where they exist should be mandatory otherwise other mechanisms will need to be developed as part of the irrigation project. All implementers and funders should be responsible for ensuring that community complaints are welcomed and addressed.
e. Implementers of irrigation schemes should be responsible for ensuring that adequate systems are in place to engage and share information with affected communities and to take their views into consideration at all stages of the project (from the needs assessment to the final evaluation). The procurement of contractors should follow good practice, and should be based on tender documents and contracts competently prepared by duly accredited professionals with all documents readily accessible.

Conclusion

The debates on food security in the drylands of the HoA appear never ending, without a clear consensus emerging. Years of regional conflict and government neglect, and reactive NGO/humanitarian interventions, have undermined traditional livelihood economies; and population growth rates are now so high that traditional

livelihood systems cannot cope. Some advocates are now suggesting that thanks to apparently abundant water sources underground, the drylands can be transformed through irrigation into local and national breadbaskets, emulating the maize fields of the moist highlands. These guidelines encourage much more caution and verification studies in the light of these expectations. They encourage dryland resource utilisation strategies that recognise the inherent strengths of the natural resource base of the drylands but in ways that promote more sustainable resource use.

These principles highlight some of the key issues to be considered when designing water and irrigation schemes in dryland areas of the HoA. They are not aimed at providing an exhaustive or comprehensive list of issues, or specific guidance, they are intended to highlight challenges and provoke suggestions or comments. Examples of successful case studies, impact assessments or other learning documents are much needed to expand them further. Please send them to the address below.

Further reading

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Copies of these principles and related technical briefs and articles can be accessed at: www.dlci-hoa.org

Please send comments/suggestions on this document and relevant good practice experiences/studies to: vtilstone@dlci-hoa.org

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