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Sustainable Flood Resilience in Refugee Camps; Combining sustainable drainage (SuDS) with WASH

Reconnaissance visit: findings and recommendations

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on behalf of the Centre for Agroecology, Water and Resilience (Coventry University)

for Elrha's Humanitarian Innovation Fund

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EXECUTIVE SUMMARY

Elrha's Humanitarian innovation Fund have commissioned Coventry University's Centre for Agroecology, Water and Resilience with Professor Susanne Charlesworth as PI, to carry out research into sustainable drainage in camps for refugees or internally displaced persons. The objectives of the programme are to create, assess and disseminate findings concerning sustainable greywater management systems and other aspects of surface water management in camps.

The programme commenced with a fact-finding field visit to Kurdish Region of Iraq (KRI), the intended locale for the research, during April 2017. Simon Watkins, director of Watkins Design Associates Ltd. and a Chartered Landscape Architect experienced in the design of landscape incorporating sustainable drainage systems attended the field visit, led by Dr. Andrew Adam-Bradford, CAWR's project manager based both in Coventry and in Erbil, the administrative centre of the KRI. The main purpose of the visit was to identify potential sites and projects for development by visiting a number of camps, meeting community representatives and liaising with authorities responsible for camp planning and management. A secondary purpose was to identify further information required in order to progress the research.

Despite the varying sites, configurations and conditions of camps in the region visited, the poor quality of water discharged into and from drainage channels within camps was found to be a common feature. Typically, households discharge kitchen and other washings water into open channels which are progressively combined into larger features running through the camps. The water in these channels is thickly coloured and smelling of ammonia indicating that some latrine water is also being discharged into the surface drainage system. Further, the resulting streams are also contaminated by accumulations of litter and other debris, in places blocking outlets and causing standing pools of stagnant water both within and immediately outside camp boundaries. In some cases, interventions have attempted to clean the water using low-tech systems, or to cover the affected channels, effectively transferring the problem further downstream.

Due to the timing of the field visit, it was not possible to observe patterns of rainwater run-off; hence to examine the potential for surface water management solely addressing rainwater.

With regard to the challenge of treating greywater to reduce its effect on the camp environment, a concept for a 'vegetated rubble-trap' was devised for potential implementation in a space designated as a new public garden in Domiz I camp. The design of this system should be carried out with proper technical input from specialists in water quality, microbiology, hydrological and landscape design. A second concept also requiring multi-disciplinary input to assess its potential, addresses scenarios in which opportunity exists to treat neighbourhood rather than household scale discharge.

However, it is suggested that the appropriate initial focus for the programme is in the form off small-scale research opportunities involving community based experiments. Potential subjects include

techniques for soil moisture retention during dry periods and rainwater harvesting, in particular at school sites.

It is recommended that the programme proceeds by mapping physical opportunities, administrative factors and resource availability in order to identify a short list of potential projects. The selection of sites will also depend upon the availability of or means to acquire a range of technical site-specific data, some of which is seasonally dependent. Most importantly, however, the success of the programme relies upon the appointment of a researcher either with pre-existing knowledge of the operational and cultural context or the capacity to spend a substantial period of orientation to the locality and the task, both prior to and alongside the development of the projects concerned.

1 INTRODUCTION

The project

1.1 The *Sustainable Flood Resilience in Refugee Camps* project was initiated in 2016 by the Centre for Agroecology, Water and Resilience (CAWR) at Coventry University, in partnership with the Lemon Tree Trust – a privately funded humanitarian project – UNHCR, the French Red Cross (FRC) and the Board of Relief for Humanitarian Affairs (BRHA) – the Kurdish agency responsible for the management of camps for refugees and internally displaced people (IDPs) in the Dohuk locality of the Kurdish Region of Iraq (KRI). The project is funded by the Humanitarian Innovation Fund (HIF) and Save the Children, in response to their 'Drainage Solutions Challenge'. In the terms set out by the HIF, the 'Principal Investigator' is Professor Susanne Charlesworth, based in CAWR's Coventry offices and the Project Manager is Dr. Andrew Adam-Bradford, based both in Coventry and in Erbil, the administrative centre of the KRI.

1.2 The principal objectives of the project are to:

- create and document pilot environmental interventions designed to improve greywater management and other aspects of surface water management in camps
- assess the impacts of these interventions on environmental and human health and flooding
- disseminate this information in the form of good practice guidance and published research

In service of these objectives, the project combines technical inputs from professionals in fields relevant to sustainable drainage with research carried out in the form of a two year full time Masters programme. Its outputs will therefore include both technical and academic materials in order to reach the widest possible audience. It is also anticipated that interventions will benefit from the knowledge and experience of the populations in which they are sited; but more significantly provide tangible benefits to those populations in the form of enhanced public health, environmental quality and functionality, community development and skills.

1.3 Simon Watkins CMLI was invited by CAWR to provide landscape architectural advice for the early stages of the project in preparation for the research component and as part of a team of project advisors of various specialist disciplines. His experience working with sustainable drainage systems includes design of proposed and implemented schemes from domestic to development scale as well as written research concerning the breadth of techniques and strategies available in various contexts.

Scope and purpose of this report

1.4 This report gathers the strands of information gleaned from a regional site visit to existing camps in the Dohuk locality made between 13th and 18th April 2017. It sets out the key findings from the visit, drawing out common drainage and related environmental or community issues applicable in all camps and identifying challenges and opportunities for intervention specific to individual camps, setting out the information required for each. In addition it suggests more general avenues for related practical research. Notes are included on the research environment and priorities suggested for the next stage of the project.

1.5 The site visits were carried out by Simon Watkins and Dr. Andrew Adam-Bradford of CAWR, Project Manager with responsibility for in-country liaison and organisation, accompanied by Akram Hassan Mohammed Al-Nuaimy, who assisted with linguistic and cultural interpretation. Some of the commentary in this report relies upon his knowledge of the localities visited.

Political, operational and geographical context

1.6 Information in this sub-section includes details drawn from the Risk Assessment prepared for the site visit by Dr. Andrew Adam-Bradford.

1.7 In 2003 following the American occupation of Iraq, the KRI became a self-autonomous region. This has allowed the Kurdish forces, known as the Peshmerga, to seal the border of the KRI and implement strict border entry controls, ensuring that since the American occupation in 2003, the KRI has not been subject to the violent sectarian violence that has plagued the rest of Iraq.

1.8 Erbil, the capital of the KRI, is also the Iraq home of several American gas and oil companies, has a fully functioning British Council office with UK staff in attendance and hosts the Iraqi headquarters of many international NGOs based in Iraq. All project activities in the Dohuk Governorate are approved by BRHA.

1.9 The Lemon Tree Trust is an international programme currently implementing projects in Iraq, Jordan and Iraq. In both Iraq and Jordan the programme is supported by the British registered NGO the Human Relief Foundation (HRF), which has offices in Baghdad, Erbil, Mosul and Tikrit, with representatives in many of the cities throughout Iraq. HRF is also registered as a humanitarian NGO with the Government of the KRI.

1.10 As of January 2017, around 88,000 Syrian refugees lived in 9 camps within the KRI. A larger and growing number of camps for IDPs are also present in the region, the number of camps standing at 22 in April 2017[1]. In general, camps host populations of specific ethnic and general geographic origin. Camp populations are hence by and large either Kurdish, Arabic or Yazidi and either of refugee status (from

[1] derived from UNHCR Iraq Factsheet January 2017, downloaded from http://www.refworld.org/country,,,,IRQ,,588754804,0.html and CCCM Cluster Iraq Operational context map 26 Apr 2017, downloaded from http://www.refworld.org/country,,,,IRQ,,590875634,0.html.

Syria) or internally displaced within Iraq, although they are not in general facsimiles of specific communities from their respective places of origin.

1.11 Camps are largely laid out to similar spatial plans with basic drainage infrastructure including separated greywater and latrine water. However, the quality of construction both of infrastructure and buildings, varies strongly from camp to camp depending on its age, state of development and available funding. The diversity of conditions will be commented upon further in Section 2. Camps are constructed by UNHCR or local government and administered by humanitarian or government agencies. The initial structure, condition and provision in camps may alter post construction according to the priorities of and resources available to these agencies.

1.12 The KRI lies in the northernmost portion of Iraq, straddling the southern edge of the Zagros Mountains and the fertile plains of northern Iraq. The climate is 'semi-arid continental', expressed in a binary system of cold, wet winters and hot, dry summers[2]. The plains support rain-fed cultivation of wheat, with smaller scale production of melon and other minor crops. Soil fertility is maintained by tributaries of the Tigris River, including the Great Zab north-west of Erbil, which wash sediments and igneous minerals from the Zagros into the basin[3]. Annual rainfall is around 800mm in the mountains around Dohuk; 540mm in the plains near to Erbil. Mean maximum daily temperature is 18.5°C in Dohuk, 20.2° in Erbil; annual maxima are achieved in July and August of 32° and 37° respectively[4] (higher temperatures are recorded locally). The region is not understood to be one in which Malaria or other significant insect borne diseases are present, although as in most inhabited regions of temperate or warmer climates, mosquitoes are a commonplace irritant.

1.13 The Zagros contain significant petroleum deposits. Exploration and extraction is a growing component of the local economy and influence upon the physical environment.

The field visit

1.14 The purpose of the April 2017 visit was to identify opportunities for practical research towards the goals of the sustainable flood resilience project within the physical, cultural and economic parameters that pertain in the camps and the region generally. Specific objectives for the visit were to:

- identify potential projects for development
- conduct assessments at two or more potential sites within camps
- obtain outline data concerning the relevant camps, including site plans
- identify further information required in order to progress the research

[2] Kurdistan Regional Government website http://cabinet.gov.krd/p/p.aspx?l=12&s=020000&r=303&p=213.
[3] various sources including http://www.kurdistanica.com/?q=node/51
[4] data from https://en.climate-data.org/country/146/.

- meet community representatives and resident groups
- meet and brief representatives of UNHCR, BRHA and the Erbil Joint Crisis Co-ordination
- determine an appropriate programme for follow up visits

1.15 The visit was carried out over five days, including scheduled visits to two camps, an extended reconnaissance visit to a third and short unscheduled visits to four additional sites. These visits were designed to provide the broadest possible overview of environmental and administrative conditions within the time available. Short meetings were also scheduled with key representatives of UNHCR and Erbil Joint Crisis Co-ordination.

1.16 At the time of the visit the seasonal conditions were in transition from the wet winter period to dry, summer weather. Significant rainfall had occurred immediately before the visit, although being late in the season this did not provide a representation of the highest levels of surface water flow which may occur during the winter.

2 FINDINGS OF THE FIELD VISIT

Variance and common factors between sites

2.1 The diversity of camp environments is largely governed by two main factors: physical geography and administrative function. The impact of geography is clear upon first encountering the camps. Locations vary from hilly, mountainsides such as at Esian camp to almost level sites such as Chamisku near Zakho in north-western KRI or Qushtapa south-east of Erbil. It is clear that flatter areas are preferred by camp planners, presumably for ease of construction and management; however, other constraints such as land availability and accessibility of local infrastructure may also determine the parameters for site selection.

2.2 The differing topography of the sites selected has a profound and obvious consequence for surface and wastewater drainage in camps, with those constructed over undulating topography facing a different set of drainage challenges to those located on flat areas. Drainage systems for the former tend to concentrate surface and wastewaters in gullies and minor watercourses within camps before discharging at the boundary. Conversely the challenge for drainage in flatter areas is the avoidance of stagnant pools and the management of flooding during wet periods. In both cases, however, there is often a concentration of polluted and litter-strewn channels within the camp (see **photograph 1** below)

Photograph 1: from Chamisku IDP camp near Zakho

2.3 Administratively there is a difference in resourcing and management of camps for IDPs as opposed to those housing refugees. Initially laid out to higher spatial and building standards, refugee camps tend to increase in density over time, evolving to accommodate new populations from a range of locations. There is therefore a diversity of form and cultural expression reflected in the housing, economic activity and community life of these sites that is less obvious in some of the less well-resourced IDP camps. However, examples exist of both refugee and IDP camps benefiting from targeted external humanitarian investment, such as that provided by the German government funded agency GIZ in Kabarto IDP camp near Dohuk for the creation of a public park (**photograph 2**); or the installation of an experimental greywater treatment and irrigation system in Darashakran refugee camp.

Photograph 2: German Government funded park at Kabarko IDP camp

2.4 Concentration of contaminated greywater and its disposal to watercourses is a common problem in all camps. This partly results from the prevailing strategy of collecting washing water from individual households together with surface run-off in open channels, progressively aggregating these into larger channels until they discharge to drains and other watercourses at the camp boundary, the resulting polluted streams in every case combining with accretions of litter and larger household detritus (**photograph 3**). Whilst kitchen and laundry washings may not typically carry heavy effluent loads, the ammonia-rich odour and unnaturally dense colouration of these greywater streams also indicates that contamination from latrines is widespread. The explanation given is that individual householders once in place tend to move and reconnect sewerage within their homes, bypassing the infrastructure designed to carry foul water to slurry tanks separately from surface and greywater. The validity of this claim could not be tested within the scope of the field visit, although the physical qualities of surface wastewater noted above suggested it is a credible explanation.

Photograph 3: watercourse exiting Darashakran camp

2.5 That the approach to management of washings and run-off water is common across all camps visited is unsurprising in light of the fact that this is also the prevailing approach taken in the smaller towns and villages locally; hence a reasonable starting point for the design of systems implemented by agencies operating within the region. The crucial differences with camps are however the high density of relatively large populations, the lack of waste management facilities and the generally lower standards of sanitation available, so that the consequences of poor wastewater management upon public health are potentially more severe. It may also be that the perception of camps as temporary settlements – perhaps permeating every aspect of the camp community – facilitates a casual attitude to waste, such that littering and generally poor waste management is tolerated by residents and administrators alike.

2.6 It was not possible to witness the effect of prolonged or heavy rainfall on camps. However, it is understood that flooding affects many camps during the winter season; particularly the lower regions of those constructed in flatter areas. Although soil type and hydrology vary from site to site, it appears that infiltration rates are low in many of the sites visited. A site-specific understanding of hydrology is a recommended area of study as set out in Section 5 of this report.

2.7 One administrative programme used in both refugee and IDP camps is the 'cash for work' scheme whereby residents may be hired on a casual basis by the camp authorities for construction or maintenance tasks. The aforementioned GIZ funded park in Kabarko is benefitting from this scheme, as are routine operations in Domiz and other camps.

Site 1: Domiz I

2.8 The village of Domiz is located a few miles south-west of the regional administrative centre, Dohuk (variously spelled Duhok or Dahuk in official literature and maps). Two camps, Domiz I and II, were created in 2012 to house refugees fleeing conflict in Syria. Around 85% of the residents in Domiz I – the only one of the pair visited – are Syrian Kurdish, the remaining 15% of other Syrian origin. The neighbouring and former land use is agricultural, comprising both arable (wheat) production and pasture, supported by fine silty clay soils of varying depth. Topographically, the area comprises rolling outliers to the foothills of the Zagros, criss-crossed by minor watercourses which connect downstream to the Mosul lake reservoir, including one watercourse receiving surface and wastewater drainage from the camp. Plans of Domiz I can be downloaded from http://data.unhcr.org/syrianrefugees/settlement.php?id=254&country=103&region=63.

2.9 Two visits were made to Domiz I camp, during which both camp-wide and localised drainage issues were noted as well as different weather conditions and the effect of varying daily routines on greywater flow in the open drainage channels. The first took place after an overnight shower, the main effect of which on site conditions being a weak capping of bare topsoil making the ground difficult to negotiate in places and indicating poor natural drainage. The rainfall may also have augmented flow in the surface drainage channels, although since the conditions had been dry for some hours before the visit it was not possible to verify whether this was the case.

2.10 In Domiz I, a combination of shallow 'v' channels and more substantial concrete channels covered with grates conveyed surface and greywater to the camp boundary, where it discharged to larger field drains and watercourses. One significant watercourse is culverted beneath the camp and receives outflow from surface drains within the culverted section. At the culvert's exit, the stream was observed to be heavily contaminated with suspended pollutants, litter and other debris. This watercourse continues to Kabarko IDP camp a few hundred metres downstream where until the recent GIZ funded park was constructed over its alignment, the open stream flowed through an area of untended damp scrubland. Anecdotally, the culverting of the stream through Kabarko camp was prompted by an outbreak of cholera attributed to pathogenic pollutants in the watercourse; specifically elements of latrine water being directed to drainage channels upstream.

2.11 The height of the stream exiting Domiz I is well below the surrounding ground level, so that although it exits adjacent to a large undeveloped area of the camp it is not clear whether scope to intercept the stream for treatment prior to outflow is feasible. A generic concept for on-line treatment of polluted minor watercourses is however discussed in Section 3.

2.12 Within Domiz I, an area of undeveloped land has been set aside by the camp administration for community use. Funding for a community garden to be called 'Liberation Garden' is pledged by the Lemon Tree Trust (LTT). The objectives of this project will include the establishment of communal food production including crops, agroforestry and potentially a plant nursery. The site, which is markedly sloping, also receives two streams of washing water and run-off originating between four rows of houses (**photograph 4** overleaf). Recently cut earth channels convey the streams to 'v' channels alongside adjacent dirt roads, one of which bisects the site. Prior to this intervention, the streams dissipated into areas of standing water and boggy ground. The odour and appearance of the streams indicates they are contaminated in the same way as the watercourse at the camp boundary, hence this represents an important advance. However, the treatment of greywater at this location prior to its onward conveyance or use on site forms one potential practical research project, the opportunity for which is discussed in Section 3. It was noted that the flow in the two channels was greater during the first visit than the second. Whilst flow may have been marginally affected by the drier conditions on the second visit, patterns of domestic activity according to custom were cited by Akram as the more likely cause; Friday being a day when household washing and cleaning are carried out more than on other days of the week, since its being a day of prayer means many people are not out at work.

2.13 During the second day visit to Domiz I, a consultation with local residents was held concerning the proposals for 'Liberation Garden', including an explanation that the treatment and use of the inflowing water would form part of the project. This consultation was part organised through LTT's resident organisers and community representatives drawn from the camp's residents. Although not core to the subject of this report, it is significant that the resulting feedback highlighted a desire to create a shared space which is both aesthetically pleasing and productive; aims which the multi-functional approach inherent to sustainable drainage should be well placed to support.

2.14 Domiz I incorporates a large expanse of undeveloped area above the level of the constructed part of the camp. Formerly a barracks compound, the buildings have been demolished, providing free sources of materials used by residents for their domestic purposes, including auxiliary building structures and gardening. A brief inspection of the remaining materials suggested that those of useable quality have all been claimed, leaving concrete rubble, massed concrete and small quantities of aggregate in piles around the site. A more comprehensive survey of these materials may reveal additional quantities.

Photograph 4: greywater / wastewater surface drain from between houses in Domiz I

2.15 Of the many retail outlets operated by camp residents, Domiz supports a small nursery / garden centre. The proprietor grows large quantities of plants from seed using imported non-peat based compost as a potting medium. A list of species / genus produced by this nursery and/or intentionally grown in the camp is included in **Appendix A**. Gardens are common (**photographs 5 & 6**) and whilst residents reported problems growing specific types of tree, many species clearly thrived. Some of the most successful are already irrigated with saved greywater. Programmes supporting camp greening have included provision of free trees, with one slightly misconceived effort involved supplying *Leylandii* to residents, resulting in a preponderance of this large-growing tree with few productive or ecological benefits in small gardens throughout the camp. This may be evidence that agencies have tended to offer whatever resources are available in abundance in preference to more rigorously designed approaches. No evidence was observed of mulching (in this or any camp); and when the question was put to the nursery proprietor it was not clear from his answer whether the suggestion had been fully understood. Whilst this may indicate that this may not be a technique used in local horticultural practice it should not rule out research relating to its potential role in surface water management.

Photographs 5 (above) and 6: gardens making use of a variety of available spaces in Domiz I

2.16 One school was visited during the first day. This facility comprised prefabricated buildings laid out in a courtyard with a fenced area of lawns and shrubs in the centre. Rainwater was standing in the lawn, suggesting some form of rain garden may be feasible. The potential for this type of intervention is discussed in Section 3.

Site 2: Chamisku

2.17 This IDP camp houses Yazidi communities from within Iraq. Occupying broadly flat land on the outskirts of the northern city of Zakho, the camp accommodates around 5,200 households, mainly in emergency tents with some concrete structures in the form of shared forecourts. Administrative buildings and schools are either pre-fabricated or constructed buildings surrounded by consolidated hardcore or concrete.

2.18 As in Domiz I, washings water and run-off are collected in shallow 'v' channels running alongside the mainly dirt roads. Towards the exit of some of these streams at the camp boundary, the channels are concreted, including one running through a large area of undeveloped and untended scrubland (see **photograph** 1 above). The odour and dense colouration of these waste-water streams suggested heavy contamination with various forms of effluent. In one case this included the blood of slaughtered livestock and flushings from a recently cleared domestic drain. The shallowness of the prevailing topography and the available space suggested that interception at surface and treatment prior to use or onward discharge may be feasible, depending on assessment of risk associated with the potential pathogenic load of the water concerned. This is discussed further in Section 3.

2.19 Incidental conversations with residents resulted in a mixed view of the problems associated with drainage. In one case, the resident concerned expressed no dissatisfaction with issues of water in general; whereas another resident living close to one outflow complained of the stench of the stream, particularly during summer months.

Site 3: Darashakran

2.20 This camp, situated a few miles north-west of Erbil, accommodates approximately 2,500 households of Syrian Yazidi residents. The majority of the camp's road infrastructure has recently been upgraded to tarmacked surfacing with concrete surface drainage channels. Constructed on sharply undulating ground, the camp straddles the head of a small valley through which a watercourse is partly culverted, partly open, collecting washings water and surface water from either side. As with the other camps, this was observed to be heavily contaminated with suspended pollutants and litter.

2.21 A greywater treatment pilot project has been constructed in this camp, comprising a passive aggregate-based system and storage tank designed to provide irrigation water for a series of nearby polytunnels. This system works by passing controlled flows of dirty water via gravity through a series of tanks filled with progressively finer grades of aggregate. At its lowest point, the treated water is pumped to the header tank, the outflow from which is piped to the polytunnels and distributed throughout. Notwithstanding the possible removal of some pollutants from the water entering this system, a brief visual inspection revealed that the water remains cloudy and foul smelling at the base of the treatment system (**photograph 7**). Further, water exiting the irrigation hoses around the polytunnels may be clearly seen to be dirty, also retaining the odour similar to that of the untreated water in the nearby drains. Crops being grown in and around the polytunnels include strawberries, runner beans, onions and young olive trees. Strawberries are irrigated at the base of their crowns from under plastic sheeting. However, in places where the sheeting has deteriorated, the part-treated water is spraying onto the leaves and developing fruit, leaving a brown residue. One attendant present on site reported that his earnings from the scheme had been very low to date since the quantity and quality of crops had so far been below anticipated standards. This suggests that there may be scope to adjust the physical outputs of the growing system to better meet horticultural needs and market factors.

Photograph 7: the recently installed greywater treatment system in Darashakran, which uses aggregate filtration

2.22 The quantum of space both around the treatment system and within the small valley in this part of the camp suggests that there would be sufficient capacity to devise a treatment system that benefitted not only from aggregate cleaning but from the capture of pollutants by vegetation and roots. Open settlement areas may not be advisable in the heart of a densely populated camp where the inflowing water is affected by potential pathogen loaded pollutants, although this may not rule out some form of concealed interception being devised.

Other sites

2.23 Brief visits to four other camps revealed similar challenges of greywater disposal to those described above. The issues prompting the culverting of the stream at Kabarko are noted earlier in this report. In Esian, a series of small camps for IDPs on the mountain slopes adjacent to the town of the same name (in the Shikhan locality), greywater pollutes the many gullies and small valleys interspersing the settlement. Baharka IDP camp north of Erbil discharges greywater to its boundaries, including one outflow which first passes through an area of untended scrubland sufficiently large to install some form of vegetative or aggregate based treatment (**photograph 8**). At Qushtapa refugee camp, south of Erbil, a watercourse receiving polluted greywater both from and upstream of the camp has been culverted to a distance of a few hundred metres downstream of the camp boundary, resolving a former problem whereby discharge from the camp was flooding the adjacent agricultural land with polluted water.

Photograph 8: the outflow of one main drainage channel at Baharka IDP camp

2.24 The culvert solution employed at Qushtapa has in effect transferred the problem of polluted greywater to a new location downstream (**photograph 9** overleaf). Discussions with Vian Rasheed, head of the EJCC office following the site visits suggest that scope may remain within the camp for intercepting and managing greywater at source. Mrs. Rasheed also indicated that contamination of adjacent farmland is considered a significant issue; and that solutions to drainage problems not reliant upon ongoing fuel costs or frequent maintenance are likely to be preferred.

Photograph 9: the end of the extended culvert exiting Qushtapa camp (visible in the background)

2.25 It was noted that the more recently constructed areas of Baharka permit little or no scope for planting since the space between dwellings is almost completely occupied by hard surfacing of tarmac or concrete. Not only does this prevent any natural drainage; it also leads to a harsh, not to say hostile environment for people. In effect, one practical challenge has been met by the narrowest possible solution without regard for other important aspects of the environment. It is noted here to underline the potential significance of the contribution which may be made the more holistic approach inherent in sustainable drainage design.

3 Potential interventions

General practical research opportunities

3.1 The opportunities described here relate to the scenarios and conditions observed in the camps during the field visit. Notwithstanding the anecdotal reports of flooding in some locations, since no instances of flooding due to any cause were observed during the visit, specific research opportunities into flood management could not be identified on this occasion. Further, since the drier period had not fully established, the condition of the soil profile and vegetation under drought pressure could not be observed. Hence the opportunities identified here may be added to by further site visits carried out during both wetter and drier periods.

3.2 For the purpose of this report, opportunities for practical research are grouped into two broad categories: community based research, involving elements of 'citizen science'; and infrastructural interventions intended to affect operation at the neighbourhood or camp level. Opportunities identified interpret the concept of sustainable drainage in its broadest possible sense, incorporating surplus water management, soil water and growing conditions for plants which may form part of a sustainable drainage intervention or benefit from its output.

3.3 The absence of any observed mulching in gardens or cropped areas raises an interesting potential area for community based research. A simple experiment may be devised whereby participants grow a variety of plant types in two beds, as far as possible identical but for the use of a mulch. The health and performance of the resulting plants during their growing season could then be measured in terms of growth rates, fruiting / cropping abundance and quality, susceptibility to pests and diseases or other indicators to be determined by the researcher. This relates to sustainable drainage in that where the output of a drainage intervention is water for irrigation but where the constancy of supply may not be guaranteed, measures to conserve soil moisture by reducing evaporation in high temperatures are of interest. Ideally, mulch should be sourced locally and for optimum benefits be of organic material such as fine brash, compost or leaf mould. However, the experiment may be augmented by trialling a variety of mulching media, including cardboard and plastic sheeting. Further, whilst mulching is a common practice and relatively well understood in more temperate regions and in UK gardening culture, its absence from obvious use in the scenarios encountered suggest that both functional and cultural outputs of the experiment may be of interest. This experiment may be carried out in any camp with a willing group of participants.

3.4 A further development of or adjunct to the mulching experiment may be in the adjustment of landform to better contain mulch and arrest groundwater movement. The use of swales is known in sustainable drainage as a means of surface water conveyance; in other contexts (for example permaculture and regenerative agriculture) swales are used 'on contour' to intercept and detain both surface and groundwater flows, create micro-climates and increase moisture availability. Where space permits, the effectiveness of swales or other micro-topographical interventions in maintaining soil moisture near to the outflow of sustainable drainage interventions may be studied. Some of the incidental 'public' spaces in camps may provide opportunities to carry out this research, particularly where sufficient space is available to combine this with greywater treatment.

Domiz

3.5 The 'Liberation Garden' site provides the main opportunity for practical research based on an infrastructural intervention in Domiz I camp. The problem to be addressed is how to intercept and treat the small and intermittent flows of polluted greywater entering the site, the better to make use of the water as a resource and in a way which does not require costly infrastructure, frequent and difficult maintenance or a large proportion of the space available for the garden. Neither should it result in standing pools of water in which pathogens may concentrate being easily accessed by the public. The design brief may also require the use of locally sourced materials and minimal construction effort.

3.6 A possible route for consideration is illustrated on drawing **17CS01_S1-2** at **Appendix B**. The concept is for an interception and treatment system combining elements of detention, aggregate filtration and biofiltration to maximise the use of space and limited resources. The system makes use of the prevailing slope, estimated at between 1:10 and 1:20. Inflowing greywater would be dispersed laterally by a coarse rubble field also serving to prevent easy access to the resulting sheet of surface water. This 'rubble trap' would comprise progressively smaller grade stones and would filter out first the larger contaminants (such as small pieces of litter and other debris), then heavy particles and finally suspended sediments via the smallest grades of aggregate. Natural colonisation by grasses and forbs would no doubt occur in the gravels in the lower section and together with the roots of plants intentionally placed around its periphery, these would aid absorption of dissolved pollutants and detergent residues. Plantings of fragrant shrubs around the inflow to the system would help to mask the odour of the incoming polluted water. A design objective would be to produce cleaner if not fully clean water useable for surface irrigation of plantings within the garden, at least aiding the establishment of trees which may in turn improve microclimate and water retention in the adjacent areas.

3.7 The early stage concept illustrated on the diagram requires considerable examination and refinement before implementation is considered, particularly in the light of the potential implications for public health of creating a dysfunctional system intended to treat polluted water in this context. An understanding of contaminant loads, flow volumes and infiltration potential must be gained in order to design an effective model system. It may also be advisable to design a 'fail-safe' overflow into the system to cope with incidents of higher than anticipated flow or seasonal extremes. Finally, a practical maintenance regime should be designed into the system. Hence, a collaboration involving water quality, microbiology, hydrological and landscape design expertise alongside operational knowledge from within the camp is required to bring the concept to fruition. Further, the concept assumes a sufficient quantity of stone as opposed to concrete rubble remains available from within the former barracks area within the camp boundary (although the purchase of equivalent material from an alternative source may not be prohibitive).

Chamisku

3.8 Within this camp at least one large and relatively flat area of untended scrubland already hosts one of the main surface drains conveying washings water and run-off to the camp boundary. On infrastructural intervention may be to utilise this space for a neighbourhood scale on-line passive water treatment system. However, it should be understood that since the field visit did not take place at a time when potential flooding issues could be observed, any such system may need to take account of factors beyond the scope of this initial study.

3.9 A diagram illustrating a potential system is given on drawing **17CS01_S1-3** at **Appendix B**. In this scenario, interception and the first stage of treatment are provided by a settlement pond. Given the potential hazards to public health, this pond would be surrounded by secure fencing; and given the odour and unsightly appearance of the inflowing polluted water, substantial plantings would be placed around its periphery, albeit with gaps allowing for natural surveillance. The pond would be sized according to estimated flow volumes; its depth would be sufficient to enable settlement of the heavier particles and any suspended solids. The outflow would be in the form of a weir, leading to the next stage of treatment, based on a winding channel planted with reeds and other marginals whose role would be to intercept some of the remaining pollutants. As with the smaller system conceived for Domiz I, the output of this system could be intended for irrigation. Alternatively the purpose may simply be to clean dirty water originating in the camp that would otherwise pollute the adjacent agricultural land downstream.

3.10 For the reasons give above, standing water has drawbacks in the context both of a camp and in an environment where it may provide breeding sites for mosquitoes and other potential insect disease vectors or irritants. Alternatives to a settlement pond may include settlement tanks, although providing sufficient of these could be highly expensive both in capital and operational terms; or a larger development of the rubble trap mechanism described for Domiz I above.

3.11 As with the Liberation Garden system, this concept requires the attention of a multidisciplinary design team to ensure an effective solution is devised. The potential effect of surface water flooding on the system should also form part of the design brief.

Darashakran

3.13 The recent greywater treatment installation in this camp indicates a commitment to the idea of recycling waste water for productive ends. However, the performance of the resulting system may not be as effective in treating the water as originally anticipated. Nonetheless there may be scope to add a level of treatment to the water between the output of the aggregate beds and the header tank in the form of vegetative treatment using the undeveloped space on the slope below the installation. This could comprise a series of terraced basins and weirs, planted with marginals to the foot of which the existing pumping mechanism would be relocated. The sizing, layout and planting of this adjunct would require careful planning based on knowledge of the site. Its implementation would also no doubt require the co-operation of the system's original designers as well as camp administrators who may be convinced of the efficacy of the existing system.

Other sites

3.14 In all cases the challenge of drainage in the camps visible during this field visit was one of water quality: how to recover useable clean water from the contaminated flow emanating from domestic buildings. The problem may be one of education as well as function, since it rests partly on individual residents redirecting latrine plumbing to outflow into the greywater system. It is clearly also culturally normal within this region for washings water to be managed via surface channels, so that any interventions within camps would run against the broader grain of local practice. Larger scale interventions such as that suggested above for Chamisku should be considered a second resort of lower priority than small scale systems close to source. This is because managing waste and excess water at source is more efficient than conveying greywater from many sources to a collection point prior to treatment and hydrological management as it omits a level of infrastructure that would otherwise be required. However, reasons why local control of flows may not be feasible could include lack of space within the domestic setting, lack of understanding or willingness by sufficient numbers of residents to utilise domestic greywater management systems and the complexity of potential maintenance responsibilities in the face of system breakdowns at domestic or community scale. These factors may be of interest in the research forming part of this programme.

3.15 Nonetheless wherever a small amount of space is available close to dwellings in camps, opportunities may exist to capture and treat water discharged directly from kitchens. Ideally such discharge would be intercepted at source at the household level. In the majority of cases, however, the outflow from individual households is located in a narrow strip of space between the backs of neighbouring dwellings. These spaces are not generally very accessible or amenable, making the potential use of any filtering or settlement system potentially quite unappealing. Recycling household water at source may therefore involve either capture in containers and manual transference to the place of use or costly re-ordering of internal plumbing. The potential for this was not examined in the field visit but could be investigated as part of ongoing community based research.

3.16 There may exist further opportunities for infrastructural interventions in and around administrative facilities; particularly schools. As has already been noted, the school complex visited briefly in Domiz I presented the physical potential to create a raingarden – i.e. a planted area designed to capture and benefit from run-off water. Other schools observed for example at Chamisku and Darashakran which appeared to lack any green space or shelter outside the building could also benefit from devices designed to intercept roof run-off, such as biofiltration planters: raised beds irrigated via downpipes from building roofs, filled with soil laid over aggregate and incorporating an overflow to the existing drainage system. The research outcomes of such a project would include data on the effect of planting on microclimate or the effectiveness of various drainage and growing media. Researchers may also investigate whether aspects of the work could be integrated into the educational curriculum.

4 Research environment

Agencies, local government and academic institutions

4.1 The agency with overarching responsibility for infrastructure providing for refugees is the United Nations High Commissioner for Refugees (UNHCR). This is the organisation which plans and implements the majority of refugee camps in KRI. Once established, however, camps are handed over into management by local government or agencies such as Board of Relief for Humanitarian Affairs (BRHA). These organisations carry out the challenging and often messy business of overseeing the camp's development as new arrivals swell the population, new infrastructure is required and 'old' infrastructure is overwhelmed by weight of numbers. Management culture, hence priorities vary from organisation to organisation. However, the relationship with the numerous management organisations and NGOs lends it a potential role in sharing best practice and knowledge transfer.

4.2 The current WASH (Water, Sanitation and Hygiene) Officer is Giorgio Amadei. Temporarily in post, his stated objective is to further UNHCR's 'Settlement Strategy' by improving planning and integration of new camps. This would involve a more holistic and site-specific masterplanning process than is typically followed in the design of camps; one influenced by the functioning of the existing landscape hence avoiding some of the pitfalls of standard templating. Whilst committed to this idea, however, his placement in the role will come to an end by the middle of summer 2017. It may be hoped that his enthusiasm for an enlightened camp planning approach may influence the selection of his successor; in which case, the ground for developing the sustainable flood resilience project in a more strategic direction (hence effectual at a broader level) may be fertile. Nonetheless this is no more than speculative at this stage.

4.3 The Erbil Joint Crisis Co-ordination are responsible for the management of camps in the Erbil area. As noted in the previous section, Vian Rasheed of EJCC expressed general support for improved drainage schemes not requiring a high level of maintenance, although she also considered that 'potential may be limited'. Her suggested sites to investigate further were Qushtapa and Basirma camps. (The latter was not visited on this occasion.)

4.4 BRHA is a regional agency responsible for the management of camps in the Dohuk region. Madyan A. Abbas is WASH Officer for the organisation. Whilst facilitating and accompanying the field visit to Chamisku he expressed support for the principles being explored by the sustainable flood resilience programme, in line with the BHRA objective to 'enable the beneficiaries to access the basic needs in a sustainable manner and with dignity'[5].

[5] http://www.brha-duhok.org/

4.5 Thirteen public and twelve private universities are based in the KRI, many of which have architectural and engineering faculties and departments. The potential for academic partnership to facilitate knowledge transfer and provide support for research activities in the field may be a worthwhile subject for investigation at an early stage of the sustainable flood resilience programme. Academic support in-country could also be an invaluable source of knowledge and guidance for the research student assigned to the programme.

Resources and facilities

4.6 Global connectivity in the region is fair to middling, with patchy standards of wireless communications, depending upon provider. There are currently no offices in which researchers may be based during extended field work or for the purpose of local project management. A fixed base from which to work would nonetheless be a useful anchor for individuals and teams contributing to the project. Clearly additional benefits may be gained by securing offices located with or alongside other organisations with complementary objectives. Negotiating agreements to use the offices of a partner NGO during extended visits may therefore be the ideal strategy.

4.7 With regard to the specifics of the project, an early task will be to obtain a picture of the economic infrastructure available to support the implementation of proposed drainage features. Some indication of available resources and structures was gained during the field visit: notably the pre-existing 'cash for work' scheme in which camp residents are provided with casual employment in construction and maintenance duties; and the existence of a wholesale nursery industry in the Dohuk area. A more comprehensive picture would include:

- audits of physical resources within the control of camp management at each site (e.g. demolition waste)
- an understanding of the quarrying and aggregate industry in the region
- survey of specialist landscape construction materials available within the local / regional economy – e.g. geofabrics, wire mesh, timber, sand, mulch, compost
- identification of all local plant nurseries and their stock range
- audits of project management and construction management skills amongst residents participating in 'cash for work' at each site
- identification of key consultancy skills and expertise available locally; these may include surveying, water quality analysis, micro-biological, soil, geotechnical, hydrological, botanical and horticultural, although not all designed interventions would require expertise in every area
- identification of potential contractors capable of larger scale landscape works should these prove desirable.

5 Conclusions and recommendations

Priorities

5.1 There are a number of directions in which the sustainable flood resilience project could be taken forward, as outlined earlier in this report. In particular, a variety of practical projects may be feasible addressing different aspects of drainage, varying scenarios particularly with regard to pollutant loads, and at all scales from the household to the neighbourhood.

5.2 In a context where there appears to be a great need the temptation is to approach the most substantial challenges as soon as possible in order to obtain the most impressive results. However, this is also a context in which the systems designed are likely to be novel and poorly understood, resources for their construction disparate and limited, understanding of local culture, needs and networks of potential support imperfect (albeit developing). In such a context, starting with small interventions enables trust and confidence to be established, precedents set and knowledge gained, to become a foundation for subsequent, progressively more significant projects. Conversely, there is a danger in making great claims for major projects in advance in order to gain support for ideas which when implemented fail to achieve their promised objectives.

5.3 Of those potential interventions described in this report, it is considered that the initial priorities should include:

- a mulching experiment to identify any benefits to soil moisture retention
- a study of how micro-topographical adjustments in the form of swales and small impoundments around trees aid soil moisture retention, with or without mulching
- rainwater harvesting in various forms at school sites (e.g. rain gardens and raised biofiltration planters)
- a model ‘vegetated rubble-trap’ based interception and treatment system for the Liberation Garden site at Domiz I camp

It will be immediately clear that these priorities lean more to the community based research scale than the infrastructural scale. This bias presents opportunities for a range of outputs and benefits, by building individual and community capacity, spreading knowledge likely to benefit communities on return to their home regions and enhancing research quality by broadening the base of research inputs to include qualitative information and potentially the dormant expertise of individuals with relevant existing skills.

Information required

5.4 The programme will benefit from an initial mapping exercise to locate all physical opportunities, administrative factors such as the capacity or willingness of camp administrators to facilitate projects and the resources of potential use discussed in Section 4. This information will be more available for some sites than for others and this availability may assist in narrowing the choice of projects to a manageable shortlist. Notwithstanding the value of this exercise in identifying a range of possible projects, given the depth of existing involvement at Domiz I by LTT and the clear commitment to the Liberation Garden project, the model interception and treatment system should be included on this shortlist.

5.5 In addition to resource mapping based on the list given in Section 4, practical information required for any site in which a physical intervention is planned includes:

- climate data specific to each location
- hydrological factors – infiltration rates in the specific site to be treated
- soil analysis – type, physical and chemical composition, acidity, condition in the specific site to be treated
- spatial survey including topography
- flow rates for water entering the site to be treated and how these vary daily and seasonally
- pollutant load in water entering each site to be treated
- intended onward use for any water exiting the system and adjacent land uses
- available positive drainage connections (either by surface or sub-surface drains) for surplus outflow during unusually high rainfall

This information is likely to require greater depth for those interventions intended to treat heavily polluted water as opposed to those which simply manage rainwater, although the significance of each factor should be considered in every case.

Programme and research team

5.6 For two reasons it is recommended that a further visit be carried out prior to the commencement of the next season of wet weather. Firstly, additional project groundwork would be beneficial, including the establishment of working relationships with camp administrators and their managing organisations; and gathering of information for the resource analysis set out in 4.7 and the mapping exercise recommended at 5.4. Secondly, since the interventions to be designed in the course of the programme will need to be resilient to both wet and dry extremes, observation of the interaction between drainage, soil and crop management during the driest periods of the year is essential.

5.7 An extended working visit should take place during the autumn of this year, focused on the sites selected following the shortlisting and enabling the key challenges of each site to be surgically identified as wet weather sets in. This visit would coincide with the construction of the first interventions and should be followed up later in the subsequent winter to enable the 'worst case' to be studied: i.e. the interaction of greywater with the ground at its most saturated condition, including both areas in which interventions have been implemented and those not benefiting from interventions. A minimal schedule of visits would finally include field work in the summer of next year to assess the efficacy of the implemented systems during the dry period.

5.8 As with all environmental design and sustainable drainage in particular, the suggested lines of research and project development require a solid base of information to be gathered. Along with explicit knowledge, however, the researcher concerned will need to build an implicit understanding of the cultural and operational context applicable to refugee camps and the NGO environment. With this in mind, perhaps the clearest and most useful output of the field visit was to highlight the complexity of relationships, responsibilities and administrative priorities of the various agencies involved in camp planning and management, driven by their various political and economic priorities which may or may not support the focus on sustainable drainage or greywater management suggested by this programme. To enter this environment from a standing start even with the advantage of experienced contacts would require some weeks or perhaps months of orientation, grounding and networking. It is therefore suggested that an individual with pre-existing exposure to the context in play be selected to lead the research; and that notwithstanding any experience held by this individual, the programme would further benefit from their being based in the field for longer periods than the total of 3 months originally envisaged would permit, albeit spread over a number of visits as necessary and appropriate.

5.9 In summary, the ideal candidate would be one who already has extensive experience not only of the NGO context but of operating in Iraq and the KRI in particular. However, as should be clear from the discussion in this report, the design of sustainable drainage systems – especially those whose functions include the treatment of polluted water – is a multi-disciplinary task. The principles may be simple but the specific solutions should be carefully planned with all significant implications considered and worked through to ensure that what is constructed does not lead to increased or unintended hazards. Hence, this individual should also continue to be supported by specialist expertise available both locally and where not present in Iraq, from CAWR's team of advisors. Adequate resources should be set aside within the scope of the programme to ensure this support can be provided when necessary.

Concluding remarks

5.10 On the strength of this short field visit it was possible to identify a few areas where substantive practical interventions may be explored, leading to research of perhaps modest intellectual value whilst nonetheless requiring significant depth of expertise in a number of areas to properly realise. Hence, notwithstanding the undoubted strength the presence of a dedicated academic researcher spending extended periods in the field will bring to the programme, it should be understood that the most significant benefits of this programme are the practical improvements made to the environment within camps as well as to reduce their impact upon adjacent land, and with the potential to influence the manner in which future camps are planned; rather than its academic outputs per se. The two are of course linked but it is the practical, humanitarian goals which should be held uppermost as the ongoing resourcing of the programme is managed and which form the basis of the motivation behind the work.

APPENDIX A

Plants intentionally grown within Domiz I camp

The following list was collated from visual surveys of vegetation in planted gardens and on sale in the retail nursery on the camp's main shopping street.

BROADLEAVED FORESTRY TREES

Acacia
Eucalyptus
False Acacia
Judas Tree (*Cercis*)
Unidentified species planted for shade, similar overall leaf form to Ash (*Fraxinus*) species but with broader, serrated leaflets

FRUIT TREES

Almond
Apple
Apricot
Avocado
Lemon
Olive
Pomegranite
Turkey Fig

CONIFEROUS TREES

Dwarf Chusan Palm
Leyland Cypress
Pine sp.

CLIMBING PLANTS

Common Ivy
Grape Vines
Honeysuckle
Jasmine

SHRUBS

Blueberry cvs.
Evergreen Euonymus cvs.
Lavender
Rosemary
Roses

HERBACEOUS CROPPING PLANTS

Basil cvs.
Broad beans
Cabbage cvs.
Coriander
Kale
Lettuce cvs. (Romano style)

Mint cvs.
Onion cvs.
Parsley
Spinach
Strawberries
Tarragon
Tomatoes

ORNAMENTAL FLOWERS

Artemisia stelleria
Chrysanthemums
French Marigolds
Perlagoniums
Primula cvs.
Sunflowers
Wallflowers

SUCCULENTS

Cacti sp.
Agave sp.

APPENDIX B

Conceptual diagrams: passive greywater treatment