

# Book of Abstracts

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*Healthy Lands - Healthy People*

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## Table of Contents

<b>AFFORESTATION IN DRYLANDS.....</b>	<b>10</b>
FAO forestry case studies and restoration guidelines in support to combating desertification in dryland	10
Kenya's' efforts in afforestation and combating desertification of the drylands.....	10
Selection of <i>Pistacia atlantica</i> genotypes and populations for successful dryland afforestation.....	10
Relationships between hydraulic parameters, anatomical traits and drought resistance in <i>Pinus halepensis</i> (Aleppo pine) ecotypes .....	11
<b>AGROECOLOGY .....</b>	<b>12</b>
Comparative analysis of the environment and productivity of Cowpea in two contrasting agro-ecological zones; The Kalahari Desert and Eastern Hard Veld of Botswana.....	12
Sustainable farming by indigenous people in the Namib Desert .....	12
Land use and management practices used by smallholder agricultural farmers in semi-arid areas of the North-West province in South Africa: A review .....	12
Economic evaluation of biological rodent control using barn owls <i>Tyto alba</i> in alfalfa .....	13
Development of IPM tools to control <i>Tuta absoluta</i> in open field tomato crops in Israel .....	13
Mismanagement of agricultural soil as a cause for desertification .....	14
<b>BUILDING ECONOMIC RESILIENCE IN THE DRYLANDS .....</b>	<b>14</b>
Enhancing livelihoods through climate change adaptation: Challenges and lessons from practices of smallholder farmers in Ghana .....	14
The Economics of Land Degradation –An Initiative for Improving Land Use Management and Promote Resilient Economic Development.....	15
A new perspective on the various constraints to participation of sub-groups from the same ethnic minority in a formal business economy: The case of Israeli Negev Bedouin.....	16
<b>CARBON FOOTPRINT.....</b>	<b>16</b>
Buildings and Carbon Emissions: Sources and Sustainable Solutions for Reduction .....	16
Remote Indigenous community water management and related carbon impacts .....	17
Rapid mitigation of global warming by dryland rehabilitation: a win-win development strategy for marginal dryland areas .....	17
Onsite carbon and nutrients recovery from dairy manure waste in a rural desert farm by hybrid hydrothermal carbonization and gas biofiltration .....	18
Integrating anaerobic manure digestion with algal cultivation for decentralized near-zero discharge waste management .....	18
<b>CLIMATE CHANGE.....</b>	<b>19</b>
Fluctuation in precipitation levels and out of ordinary rain events in the Southern Arava Valley 1949-2014.....	19
Connecting climate change and surface water flows to aquifer recharge and groundwater management	19
Climate Change and its Uncertainty in Drylands of Kachchh, Gujarat, India .....	20
Erosion control, restoring soil fertility and agro-economic valorization of degraded land by inclusive watershed management: The case of South West of Burkina Faso .....	22
<b>CLIMATE HISTORY, DROUGHT AND DESERTIFICATION IN THE ANCIENT NEAR EAST .....</b>	<b>23</b>
Drought, Economic Crisis and Demography: Two Case Studies from the Byzantine and Early Arab Near East.....	23
Drought in Jordan: P/PET Classification and Tree Rings.....	24
Post glacial and Holocene Dead Sea levels as indicators of Near East paleoclimate .....	25
Climate Change and Runoff/Floodwater Capturing Agriculture in the Central Negev: Dating, Temporal and Causal Relationships? .....	25
Climatic deterioration during the Middle Bronze Age revealed by subfossil wood from the southern Levant .....	26
Climate Change, Human action and Desertification in the Wadi Faynan, Jordan.....	26

A rapid landscape change in 6th century northern Jordan: desertification, or driven by climatic extremes?27 Israel Antiquities Authority, “Man-made desertification? The new evidence from a late Neolithic- Chalcolithic occupation of Har Harif (Central Negev highlands, Israel).....	27
<b>COMMUNITY AND TECHNOLOGY IN PROJECT WADI ATTIR.....</b>	<b>28</b>
About Project Wadi Attir .....	<b>Error! Bookmark not defined.</b>
<b>COOK WORKSHOP SESSIONS.....</b>	<b>28</b>
Sustaining Residential Gardens in Arid Regions with Integrated Lot-Scale Water Systems .....	28
A multifunctional energy retrofit façade system for different climates .....	29
Recommendation for daylighting in sunny regions .....	29
Implementing energy efficiency measures for buildings in extreme climatic conditions.....	30
Green house construction.....	30
Passive and low energy architecture: the Israeli approach within the sustainable building standard .....	30
Application of sustainable building and operating technologies in residential units – cost and benefit... 31	
The impact of a manmade oasis on human thermal comfort in a hyper arid environment: The case of Southern Israel .....	32
Environmentally responsive strategies for building design and electricity savings in hot hyper-arid regions.....	32
Cooling the cities: mitigation and adaptation techniques to counterbalance urban overheating .....	34
Improving outdoor comfort and energy consumption of a city district in a desert area .....	34
A design tool for water-efficient green open-spaces in the Israeli arid climate.....	35
Biophilia and drylands architecture: visions for future living.....	35
Sustainable development promoting local tradition: the work of Terrachidia in the M’Hamid Oasis (Morocco) .....	36
Hempcrete construction in Europe: the green alternative .....	36
<b>DESERT AGRICULTURE (DRIP IRRIGATION).....</b>	<b>37</b>
Drip irrigation to save water or economize labor? A choice experiment in remote Zambia .....	37
Drip irrigation as a strategy for water scarcity at the small scale farming community levels in the arid zones of Sri Lanka: an empirical study .....	37
Use of polymer membranes in drip irrigated systems.....	38
Drip irrigation via compost trenches.....	38
Solar-powered drip irrigation impacts on food security, economic development, and climate resilience 38	
The implications of fertigating olives with reclaimed wastewater .....	39
Technological- Innovation for Poverty Alleviation (TIPA).....	39
Why are farmers adopting drip irrigation (or not) in India? Lessons from a study of 450,000 drip purchasers in Gujarat .....	40
DIDAS: A user-friendly software package for assisting drip irrigation design and scheduling .....	40
Augmentation and enhance water use efficiency through farm pond and micro irrigation rainfed area of Kashmir valley .....	41
Agronomic and ecological evaluation on growing water-saving and drought-tolerant rice through drip irrigation.....	41
Irrigating more land with less water using water saving techniques: A review of challenges and technological options for Nguruman and Lari Wendani Schemes, Kenya .....	42
The evolution of drip irrigation: a personal account.....	42
Advances in fertigation .....	43
<b>DESERT ECOLOGY .....</b>	<b>43</b>
Resilience and recovery of semi-arid annual plant communities to drought .....	43
Bee and plant species diversity and interactions along climatic and land use gradients: the case of Wadi Nar and Wadi Daraje.....	44

Investigating spatial and temporal patterns of plant health of <i>Welwitschia mirabilis</i> in the central Namib Desert .....	44
<b>DESERTIFICATION IN MONGOLIA.....</b>	<b>45</b>
Transformation of traditional organization in the transitional period of rural Mongolia.....	45
Explaining spatial variations in climate hazard impacts in western Mongolia .....	45
Contrasting strategies in a similar environment: comparing Gobi pastoralists' livelihood trajectories in transformed Mongolia and China .....	46
Dry land pasture degradation and climate change adaptation development for Gobi region in Mongolia.....	46
<b>DESERTS AND DRYLANDS IN ANCIENT LITERATURE AND ARCHAEOLOGY .....</b>	<b>47</b>
Monasticism in arid and semi-arid landscapes in late antiquity: Between holiness and economy .....	47
Cities in the steppe drylands: The case of Qara Qorum, capital of the United Mongol Empire .....	47
Trails and people: Selecting a route in the desert .....	47
The people that came and went: Har Michia, resources and landscape, an archaeological approach .....	48
What a relief – stone architectural decorations in the Byzantine Negev .....	48
Tribal towns in the Arabian Peninsula.....	48
The long wall(s) of China: An ecological or cultural marker of the borders between the agricultural region and the drylands.....	49
The role of the desert in early Egyptian monasticism and Christian hagiography.....	49
The Negev in imperial eyes: A frontier between image and reality.....	49
The ambivalent attitude of Biblical scribes towards the Desert.....	50
<b>ENVIRONMENTAL EDUCATION .....</b>	<b>50</b>
Inquiry in science or scientific inquiry: What official documents say and what teachers believe?.....	50
Construction of new sense of place in an unrecognized Bedouin village .....	51
This road is in my space-map - Highway 31 as a place in the Israeli Negev.....	51
(De)centering the margins: The role of environmental education in facing the challenges of desertification.....	51
Hebron Stream as a place identity component for primary school students living in nearby Bedouin communities.....	52
Collaboration of multicultural knowledge through Communication Technology - understanding the social-ecological coupled systems of the desert.....	52
Learning about the desert or about the coast line: A dichotomy or a continuum?.....	53
<b>FAMILY PLANNING AND DEVELOPMENT IN DRYLANDS .....</b>	<b>54</b>
Status of women, sustainable forestry and family planning in Kenya .....	54
Pronatalism as cultural worldview: An important challenge for environmentalists and advocates for lower population .....	54
Comparing the Drivers Behind Differential Birth Rates in Israel.....	54
<b>GEOLOGICAL ASPECTS OF DESERTS AND DESERTIFICATION .....</b>	<b>55</b>
Life on rock – Rock outcrops as key component of the natural and human systems in the arid and semi-arid Areas.....	55
Pedogenesis in response to Quaternary-scale aridification of the Negev desert, Israel .....	56
The geological background of desert environments in the Middle East: timing, processes and future predictions.....	56
Sand dunes and the downwind accretion of desert loess .....	57
<b>KIDRON RIVER RESTORATIONS.....</b>	<b>57</b>
Searching for Environmental Dignity in the Kidron/Nar Basin.....	57
<b>MATH SESSIONS: ECOHYDROLOGY OF DRYLAND LANDSCAPES; MATHEMATICAL ASPECTS OF DESERTIFICATION; DRYLAND LANDSCAPES AS PATTERN-FORMING SYSTEMS .....</b>	<b>58</b>

Rainfall-infiltration-runoff relationships in a semi-arid hillslope and their interactions with vegetation cover.....	58
Critical and gradual transitions in spatially extended ecosystems .....	58
Early-warning signals for desertification: a percolation framework.....	58
Competition of species using a synthesizing unit approach.....	59
Adopting a spatially explicit perspective to study the mysterious fairy circles of Namibia .....	59
Climate changes in precipitation variability and dryland vegetation.....	60
Reversing desertification: less is more.....	60
Wavelength selection and hysteresis in mathematical models of banded vegetation .....	60
Stochastic desertification .....	61
Modeling power-law edge-interior area decline in shrub and soil patch patterns along a climatic gradient.....	61
Relationships between primary productivity and rainfall in a semiarid ecosystem .....	62
<b>NUTRITIONAL AND FOOD SECURITY .....</b>	<b>62</b>
A Global Food System without Food Reserves: A Recipe for Disaster .....	62
On-farm performance of three elite sweet potato varieties at Mukuyuni in Makueni County in semi-arid eastern Kenya.....	63
Development of water saving and drought resistant rice and culture practice for growing WDR by means of drip irrigation.....	63
LC-MS analysis of cucurbitacins in Namib endemic fruit -Nara ( <i>Acanthosicyos horridus</i> ) .....	64
<b>ON-SITE WASTE COLLECTION.....</b>	<b>64</b>
Assessment of pathogenic bacteria in greywater systems and irrigated soils .....	64
Quantitative assessment of microbial risks associated with greywater.....	65
Greywater reuse: Challenges and opportunities.....	65
Securing water supply in Israel: An eco-innovative water treatment solution applied to the desalination brine effluent.....	66
The condensing greenhouse - a holistic, sustainable approach to small-scale water desalination in remote regions - using solar, wind and wave energy .....	66
Solar driven removal of contaminants from brackish waters using capacitive deionisation technologies.....	67
<b>POSTER SESSION.....</b>	<b>67</b>
DIDAS - A user-friendly software package for assisting Drip Irrigation Design and Scheduling .....	67
Long-term effects of woodland planting in drylands on soil fertility and native vegetation productivity .....	68
Spectral identification of biological soil crusts in the Northern Negev .....	68
The role of dew in desert plants .....	68
Relating landscape ecohydrology to vegetation patchiness in a long-term field experiment .....	69
Growing safflower ( <i>carthamus tinctorius</i> L.) in the semiarid northeastern Brazil .....	69
Semiarid northeastern Brazil: general aspects .....	70
Shrub cover as a stimulus of arthropods community in desertified regions .....	70
Feedback mechanisms to model gap patterns – Fairy circles in Namibian drylands.....	71
Natural Biological Systems for sustainable decentralized water treatment: principles and case studies..	71
Thermal ecology and locomotor performance of the critically endangered stout iguana ( <i>Cyclura pinguis</i> ).....	72
Emergence, growth, and survival of seedlings in a mobile sandy desert with phytogenic mounds: a spatiotemporal study of the effects of ecological drivers.....	72
Preliminary screen of 30 new introduction cultivars of <i>Ziziphus jujuba</i> .....	73
Environmental conditions of urban spaces in a desert town: the case of Mitzpe-Ramon, Israel.....	73
Land-use change, a case study from southern Italy: General implications for agricultural-subsidy policies.....	73
Land degradation and ecosystem function loss.....	74
A strategic environmental management plan to monitor and mitigate the effects of uranium mining in the central Namib, Namibia .....	74
Stochastic Desertification .....	75
"Apparatus" Patent, Capabilities and Purposes.....	75

<b>PUBLIC HEALTH .....</b>	<b>76</b>
Brucellosis in the Negev: Epidemiological, social and economic perspectives.....	76
Installation of solar panels in houses of chronically ill infants and children in the Arab Bedouin villages of the Negev for the operation of medical equipment and reduction of use of diesel powered generators.....	76
The factors influencing the sexual and reproductive health of Eritrean asylum-seeking women while en-route to and in Israel .....	77
Climate change and health - an Israeli perspective.....	77
Levinsky Clinic for detecting sexually transmitted diseases and HIV- Access to health and social services for people with no legal status or asylum seekers.....	77
Diabetes Care in Palestine; between Reality and Challenges .....	78
Desertification and Infant Mortality in Colombia.....	78
Keynote: Perspectives on climate change from ecological public health .....	79
Tuberculosis screening and disease among migrants from the horn of Africa arriving in Israel.....	79
Climate Change Impacts on West Nile Virus .....	79
Infectious Disease Ecology and Epidemiology: Case study; The eco-epidemiology of Cutaneous Leishmaniasis caused by <i>Leishmania tropica</i> in Bethlehem villages .....	80
Ecosystems Services and Health.....	81
<b>PUBLIC HEALTH WORKSHOP.....</b>	<b>81</b>
Participatory action research using mobile methods.....	81
<b>REMOTE SENSING .....</b>	<b>82</b>
Using Visible Spectroscopic Based Analytical Methods for Assessing Labile Carbon on Agricultural Areas .....	82
Modeling Shrublands Biomass Using Radar Polarization Parameters .....	82
Evaluating and predicting water consumption by irrigated agriculture in the semi-arid regions of the north-western Negev, Israel .....	83
Remote sensing of evapotranspiration over irrigated farms in central Arizona, USA.....	83
The NASA land-cover and land-use Change program: Focus on drylands .....	84
Present, past and future of global distribution of <i>Pistacia</i> species in relationship to climate change - remote sensing and GIS analyses.....	84
Re-greening of the Sahel - A myth? Case studies from Mali, Niger and Darfur/Sudan .....	85
Structural changes of desertified and managed shrubland landscapes in response to drought: Spectral, spatial and temporal analyses.....	85
Monitoring dynamics of grassland resources in southeast inner Mongolia and Great Wall Region, China.....	86
Monitoring for drivers of land degradation using remote sensing and GIS in Mongolia .....	87
Drought monitoring in Northeast China using an improved Temperature Vegetation Precipitation Index (iTVPI) based on MODIS imagery and meteorological data.....	87
Some results of space monitoring of droughts in Kazakhstan .....	87
Using time series of satellite vegetation indices for analyzing of the dynamics of vegetation degradation in Kazakhstan.....	88
Change detection in drylands: validity of the Tasseled Cap transform.....	89
<b>RETHINKING AGRICULTURAL TECHNOLOGIES .....</b>	<b>89</b>
Sustainability Innovations in Project Wadi Attir .....	89
Alternative technologies and landscape planning for local development: A case study and pilot project for water management and biodiversity conservation in the Atacama Desert.....	90
From transfer to translation: Using systemic understandings of technology to understand drip irrigation uptake.....	90
Adoption of water saving technologies in drylands agriculture - what will it take? Evidence from Western India.....	91
<b>SOIL AND LAND RESTORATION.....</b>	<b>91</b>

Appropriate integrated nutrient management and water harvesting options for maize production in the semi-arid southern rangelands of eastern Kenya .....	91
Response of soil microbial communities to vegetation rehabilitation in semiarid sandy land .....	92
Irrigation with treated wastewater (TWW): a trigger for subsurface soil sodification .....	92
A Decision Support System for Arid Lands Restoration .....	93
Microbial secreted exopolysaccharides of induced biological soil crusts in Inner Mongolian desert soils: chemical characteristics and role in affecting water-soil relations .....	93
Using agro(eco)system services approach to assess tradeoffs of various tilling methods as a tool to improve sustainability and prevent desertification processes in Shikma Park, Israel.....	94
No adverse effect of stubble grazing on soil quality indicators in dryland wheat agro-ecosystems.....	95
<b>UK, ISRAEL, AND DRYLANDS SYMPOSIUM .....</b>	<b>95</b>
Pastoralism and water in Mongolian drylands: the effects of changing climate and the mining industry	95
Sustainable maize production and nutrient cycling in a runoff agroforestry system .....	95
Sustainable resource use in drylands: Sharing UK and Israeli expertise .....	96
Sustainable resource use in dry lands .....	96
On-farm conservation of plant genetic resources for dryland agriculture in Namibia's northern cropping regions.....	96
Augmentation and enhance water use efficiency through farm pond and micro irrigation in rainfed area of Kashmir valley.....	97
Natural Resource Management in Dryland of Kachchh - Pathways Towards Sustainability under Desertification and Climate Change .....	97
A review of factors affecting the development of smallholder irrigation and rangeland grazing Schemes in Semi-Arid Areas of the North-West Province in South Africa.....	98
Human amplification of climate hazards: 2010 floods in Pakistan.....	98
Agro-ecosystems under stress: functioning and management .....	98
Water scarcity and agricultural challenges in Chinese drylands.....	98
Water and climate change adaptation in rural Africa.....	99
Rural Water Development: Should it be an essential course for graduate students? .....	99
<b>UNCCD-SPI: LAND BASED ADAPTATION TO CLIMATE CHANGE .....</b>	<b>99</b>
The Economics of Land Degradation (ELD) Initiative - Integrating the economics of land degradation into policy making .....	99
Monitoring desertification after the AGTE.....	100
The science of making land adapted to climate change – an attempted assessment.....	100
Avoiding land degradation and restoring degraded land: A comparative analysis of Asia and Africa (Sri Lanka & Uganda).....	100
Global assessment of the cost of land degradation & strategies for achieving land degradation neutral world .....	101
The UNCCD Science-Policy Interface (SPI) and its efforts to explore the sustainable land management nexus among the Rio Conventions.....	101
Time for Paradigm Shift in How We Transfer Knowledge? Making the Case for Translational Science and Public Engagement.....	101
A method for integrated assessment of vulnerability to drought .....	102
The UNCCD, what is it all about? .....	102
An approach to the identification of indicators for land-based adaptation to climate change .....	103
<b>WATER MANAGEMENT CHALLENGES IN THE DRYLANDS .....</b>	<b>104</b>
A tale of two rivers: Pathways for improving water management in the Jordan and Colorado River basins.....	104
Transboundary aquifer assessment at the United States-Mexico border .....	104
Water resource management, ecosystem services, land use changes in the transboundary Ili river basin	104



Monitoring impacts of a critical economic sector on a critical resource: minerals and water resources in the central Namib .....	105
<b>WOMEN AND ECONOMIC CHANGES IN RURAL ARID REGIONS .....</b>	<b>106</b>
Transforming Economies and Roles: Bedouin Women Recreate Economic Change.....	106
Rural women energy security project as a social entrepreneur approach to checking desertification in rural- arid regions.....	106
Bedouin Women at the Forefront of Development through Innovative Approaches: Sidreh's Desert Gardens .....	106

## Afforestation in Drylands

### *FAO forestry case studies and restoration guidelines in support to combating desertification in dryland*

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Many dryland countries have been developing and piloting approaches and technologies to support sustainable forest management and restoration of dryland forests and degraded lands as part of their efforts to combat desertification. These include: innovative water harvesting techniques and technologies, use of treated waste water in forestry and agroforestry systems, sand dune fixation, assisted natural regeneration, community forestry and development of community-based small and medium enterprises. FAO has provided related technical support to many countries and is currently supporting the African Union's flagship "Great Green Wall for the Sahara and the Sahel Initiative (GGWSSI)"; which is aimed at improving the resilience of human and natural systems in Sahara and adjacent countries using a landscape and multi-stakeholder approach to find long-term solutions to desertification, land degradation and drought, climate change and biodiversity loss.

As a response to the request of its member countries and in collaboration with countries and various partner organizations, FAO undertook a comprehensive analysis and documentation of a range of afforestation, reforestation and restoration projects and programmes in drylands. Key factors of success and failure were identified and discussed at international expert events. A set of guidelines, "Building resilience in drylands: Global guidelines for restoration of forest landscapes and degraded lands", are being developed based upon the compiled information. The purpose of this presentation is to present FAO's case studies and guidelines and to highlight factors that would facilitate widespread uptake and implementation of lessons learnt by the dryland community.

### *Kenya's' efforts in afforestation and combating desertification of the drylands*

David K. Mbugua (presented by **Mr. Patrick Kariuki**), Kenya Forestry Service, Kenya, director@kenyaforests-service.org

### *Selection of Pistacia atlantica genotypes and populations for successful dryland afforestation*

**Orna Reisman-Berman**, Binyam Telada Abera, Bertrand Boeken, Ben Gurion University; Israel

Dryland afforestation provides various ecosystem services to humans and the environment. However, a careful selection of tree species is required to achieve a successful plantation that can tolerate the stressful conditions of dryland environments. The integration of native dryland tree species in aridland afforestation has a great potential because of the species adaptations to the natural environment. *Pistacia atlantica* has an impressive canopy and inhabits comparatively arid environments, which proposes that the species can be a good candidate for dryland afforestation.

The aim of the study was to understand the distribution of drought resistance properties, among and within the natural populations of *Pistacia atlantica* along the rainfall gradient in Israel, in order to integrate the species in dryland afforestation.

The main questions of the study were: 1. Can the species establish and develop in drought-prone environments? 2. If it can, are drought resistance-related traits found only in specific populations, or in all populations of the species along the rainfall gradient? The study hypothesis was that there is a difference in drought resistance between populations along the rainfall gradient, and that the southern population of the Negev is the most resistant to drought.

Alternatively, the drought resistance traits might be a property of a genotype and not the property of a population.

To attain the study aims and to test the hypotheses, we have used a various approaches:

1. Greenhouse experiments that tested the development of *P. atlantica* seedlings, originating from different maternal genotypes collected along the rainfall gradient in Israel.
2. A field experiment that tested the establishment and the development of saplings from various *P. atlantica* maternal genotypes;, under the KKL-dryland irrigation regime (Dry). and under a wetter irrigation regime (Wet).
3. A field experiment that investigated the development of *P. atlantica* offspring under six different irrigation regimes that vary in the amount of water given during each irrigation event and in the frequency of irrigation events.
4. A wilting experiment that imposed drought and tested the response of various saplings that represent different populations and genotypes within the populations along the rainfall gradient.

The results demonstrated that offspring of various populations and genotypes within populations, grown under greenhouse conditions, - differed in their development (i.e. elongation, stem thickening and leaf production). There was also a significant difference in development between the offspring of different *Pistacia atlantica* genotypes;, in their response to the KKL dryland irrigation regime (full field filed capacity every 45 days) and to the Wet irrigation regime supplied in the field experiment. However, a significant improvement in development can occur, only if water is provided to half or full field capacity every 15 days or less. This is inapplicable and means that the KKL irrigation regime is a cost effective regime for dryland afforestation.

In the wilting experiment, *Pistacia atlantica* saplings from the populations of Nahal Nitzana and Elot, started to wilt significantly later than all the other populations, and at that time, their soil moisture at that time was low compared to the other populations.

Based on the results, we accept the hypothesis that populations of *Pistacia atlantica*, as well as, the genotypes within the populations, indeed differ in their drought tolerance, and that some drought tolerance properties can be distinguish between the populations of *P. atlantica* along the rainfall gradient in Israel.

The rapid growth of the Northern genotypes may contribute to afforestation projects, by shortening the afforestation establishment period. On the other hand, drought tolerance properties of the southern populations show their considerable suitability for dryland afforestation. Therefore, the selection of *Pistacia atlantica* for dryland afforestation can be made either from the most drought-tolerant populations to be planted in the Negev specifically, or all along the gradient, depending on afforestation objectives.

### ***Relationships between hydraulic parameters, anatomical traits and drought resistance in Pinus halepensis (Aleppo pine) ecotypes***

**Rakefet David Schwartz;** ARO, Volcani Center, Israel; rakefetd@agri.gov.il

Trees use various strategies to cope with arid conditions. It has been shown that adaptation of wood structure and its hydraulic function are fundamental to survival in arid regions. Natural genetic variation can provide insight into which of these adaptations are most important, and direct us to the properties desirable in trees used in arid forestation.

In the current study, we utilized a trail of *Pinus halepensis* (Aleppo pine) provenances (or ecotypes) from five locations in the Mediterranean region to analyze hydraulic conductance parameters and tracheid anatomical traits. We found that the ecotypes varied in their hydraulic characteristics. This variation was supported by anatomical measurements that showed a positive correlation between conductivity and tracheid lumen diameter. Ecotypes were also varied in their cavitation resistance; which was expressed by the xylem pressure inducing 50% loss of conductivity (P50). Moreover, analyses of the bordered-pit structure and function revealed differences in valve strength between ecotypes, suggesting that stronger bordered-pits better resist cavitation and drought. We propose that adaptation of Aleppo pine to xeric habitats has been dominated by modifications of bordered-pit structure and function.

## AgroEcology

### ***Comparative analysis of the environment and productivity of Cowpea in two contrasting agro-ecological zones; The Kalahari Desert and Eastern Hard Veld of Botswana***

**Utlwang Batlang**, Goitseone Malambane, Chipso Nkomazana, Charles King Jr., Gloria Mashungwa, Flora Pule-Meulenberg, Topoyame Makoi, T. Mpuisang, Samodimo Ngwako., Scot Moroke, Botswana College of Agriculture, Botswana; ubatlang@bca.bw

Cowpea [*Vigna unguiculata* (L.) Walp.] is an economically important crop in semi-arid and arid tropical regions in Africa, Asia, and Central and South America, where it is used for human consumption and livestock fodder. In Botswana, the crop is widely grown by subsistence farmers in the Kalahari Desert and Eastern Sand Veld; with, drought stress prevails during the production period running between November and April. This is due to fact that the environment in these areas is characterized by low and unreliable rainfall coupled with sandy and low fertility soils. The study was done by determination of plant available water (PAW), and growing degree days (GDD), planting population and annual rainfall amount in the period under consideration. Estimation of in-situ potential for plant available water (PAW) was done using the sand and clay factions, organic carbon content (%OC) and cation exchange capacity (CEC). Mapping of growing degree days (GDD) and rainfall distribution in the country indicated that Kalahari Desert had more GDD but lower rainfall than the Eastern Sand Veld. Time series cowpea yield analysis showed that the Kalahari Desert area was more productive than the Eastern Sand Veld. This was associated with higher GDD due to location and timing of planting. It was also observed, that in the Kalahari Desert, higher planting population was practiced, which could have contributed to higher crop productivity. The results are discussed, in relation to the effects of management of cowpea in limited soil water resources, in the agro-ecological zones understudy.

### ***Sustainable farming by indigenous people in the Namib Desert***

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The Topnaar (or //Aonin Nama) of Namibia have been living in the Namib Desert for more than 600 years. Their renowned, precolonial subsistence economy, based on a combination of harvesting natural resources on the verge of the Namib Sand Sea and subsistence agriculture along the Kuiseb river, has been documented by archaeologists and anthropologists. Most of this research focused on their remarkable harvesting of the !nara fruit and precolonial fishing industries; with their effective livestock farming system attracting less interest. However, the traditional farming system continues to this day, in which the //Aonin farmers raise cattle, goats, sheep and equines along the linear Kuiseb river oasis in the hyperarid Namib Desert. This thin line of riverine arboreal and herbaceous vegetation, less than 500 m wide, is the mainstay of this farming system. The main source of food for livestock is the pods produced by *Acacia erioloba* and *Faidherbia albida* trees; which blossom and produce nutritious seed pods during different seasons, thus providing a continuous source of browsing throughout the year. Ironically, the //Aonin farmers suffer 'drought' conditions during exceptionally wet years when the river floods and washes away seed pods or prevents animals from crossing the riverbed to reach tree stands. The riverine system supports 214 farming households and 581 large livestock units spread along the lower course of the Kuiseb. Participatory farmer's assessments and independent monitoring of seed pod concentration and browsing effects along the river confirmed that farmers are well aware of the dynamics of this system in this extreme desert environment. Surveys indicated little evidence of overgrazing and animal malnutrition; suggesting that the traditional //Aonin farming system is extremely well adapted to the prevailing desert conditions.

### ***Land use and management practices used by smallholder agricultural farmers in semi-arid areas of the North-West province in South Africa: A review***

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Large areas (63%) of the North West Province in South Africa are semi-arid savannas and display extensive occurrence of land degradation. Smallholders in these ecosystems have adopted creative and innovative practices for sustaining agricultural productivity. This paper reviews results of studies conducted in four farming districts located in this province.

Since most of the areas in this ecosystem are marginal for crop production, the majority of the land (76%) is used for livestock production on natural grazing land (veld). Livestock farmers consider fire as a valuable tool for managing the veld. Accordingly, most of the veld was burnt annually in order to recycle nutrients from previous year's grass biomass, stimulate growth and to control the encroachment of undesirable plants. A concern over the long-term effects of fire on the sustainability of a fire-managed rangeland system was expressed (by whom?). Agroforestry, which is a land-use system that integrates woody perennials (trees and/or shrubs) with agricultural crops with or without livestock, was practiced by 82% of the households in the study. It was found that farmers in semi-arid areas selectively retained trees of *Acacia elioroba* (syn. *Acacia giraffe*) on their homesteads, crop and grazing lands. The farmers indicated agroforestry benefits of *A. erioloba* to include provision of shelter (96%), firewood 89, fodder for livestock (78%), controlling soil erosion (68%), maintaining soil fertility (56%) and improving the sustainability of the agricultural system in the ecosystem (34%).

Eighty-seven percent of farmers used a variety of amendments (including: animal manure, wood ash, crop residue, and municipal organic wastes, earthworm casts and termitaria) to supply crops with nutrients and improve soil physical properties; including structure. Animal manure was considered a key input for soil fertility management in crop production. Both aerobic and vermicomposting are used to improve the quality of the manure. As the rainfall in these environments is less predictable and highly variable, irrigation is used by 87% of the framers. Irrigation practices include: watering cans and buckets (88%), drip micro irrigation (42%), sprinklers (27%) and furrow (38%). The channeling of runoff water at non-erosive speed into a series of deep contours, infiltration pits and small dams have proved to be an effective way of reducing soil erosion while increasing soil moisture. Some farmers, whose houses are roofed with iron sheets, collect water running off their roofs by directing it into tanks via a network of pipes. Urban agriculture was also prevalent in the study areas.

### ***Economic evaluation of biological rodent control using barn owls *Tyto alba* in alfalfa***

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Rodents are common pests in various agricultural cultivations. Utilization of barn owls for rodent pest control has long been used. In Israel, the indirect effect of barn owl predation pressure on alfalfa crop yield has been examined. Using radio-telemetry, barn owls were tracked to form a density-distance function. This function was utilized on all barn owls nesting in the vicinity to form accumulated predation pressure on whole fields; which was compared to crop yield in contemporary alfalfa harvests. Results show that barn owl presence has a positive effect on alfalfa crop yield, enhancing crops by 9.4% and allowing a net profit of 32\$/dunam-year. These results are important, since they encourage farmers to use this environmentally friendly, healthy method owing to agricultural-economical considerations, thereby evading the environmental-financial conflict.

Nowadays, many farmers use this method, and some 4000 nesting boxes for barn owls are dispersed in the agricultural lands over the country. This regime, has lowered rodenticide use in agriculture drastically, both on a farm scale, and on a national scale.

### ***Development of IPM tools to control *Tuta absoluta* in open field tomato crops in Israel***

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Introduction: The moth *Tuta absoluta* Povolny (TA) is a key pest of tomatoes that originated from South America. In 2006 it was discovered in Spain and since then, its distribution in the Mediterranean region, Europe and Asia was very quick. In December 2009 TA absoluta was first discovered in Israel; and within a few months could be found all over

the country. Since its initial discovery, this pest has caused extensive damage to tomato crops in all the countries it invaded. The main means of its control is frequent applications of pesticides, which are environmentally harmful, cause health damage and their efficiency decrease due to development of resistance. Since TA is a newly introduced pest in Israel, there is no information about the relationship between population density and economical damage in local conditions; and what is the Economic Injury Level (EIL).

Research objective: To determine the relationship between TA population level in various tomato phenological stages and crop damage at harvest.

Methods: The study was conducted at Avene Eitan research station, northern Israel, in 48 screen houses, planted with processing tomatoes seedlings Ver. 9780. The seedlings were infested with TA larvae in 4 different levels: 0%, 10%, 30% and 60% of the leaflets on each plant were infested at 3 phenological stages: 1. from planting to fruit set; 2. From fruit set to color change; 3. From color change to harvest. There were 4 replications to each treatment in a complete random design. Once a week, all TA galleries were counted on 2 focal plants in each screen house. At harvest all the fruit was picked and the direct and indirect damage was determined. This experiment was conducted twice at 2012 and 2013.

### ***Mismanagement of agricultural soil as a cause for desertification***

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It is a well-known fact, that along human history, agricultural land was deserted as a result of mismanagement. Jared Diamond, in his book 'Collapse: How Societies Choose to Fail or Succeed', describes several incidences of catastrophes induced by land degradation caused as a result of human behavior. One of the famous examples, is that of the Easter Island. Whereupon, excessive tree cutting and deforestation led to severe soil erosion, starvation and even cannibalism, since there was not enough soil to grow and produce food.

About 600 years later, the present time, this phenomenon of erosion caused by intensive agriculture still occurs. According to several sources, including the Food and Agriculture Organization of the United Nations (FAO), approximately 12 million hectares of arable land is abandoned annually due to non-sustainable farming practices. In a study, that aimed to evaluate soil loss in cultivated lands, we found, that in cultivated areas in the north part of Israel (Ramat Menashe and Ramat Isaschar) an average of 20cm of top soil was removed, while soil depth in natural areas remained the same between the years 1952-2002.

Means of intensive agriculture, and especially those which are used in preparing the land for sowing field crops, leave bare surfaces. At this state, the soil is prone to erosion; which may lead to the creation of sheet erosion, rills or gullies caused by the impact of rainfall. In order to fill these grooves, farmers tend to use nearby top soil. By doing this, not only the rills and the gullies, but the entire field is eroded. As a result, the B horizon of the soil profile is exposed. This horizon is less fertile; it is usually more compact and consists of smaller particles. This layer has relatively lower permeability than the A horizon which was eroded, thus, it creates a change in the rainfall-runoff relationship and accelerates erosion.

The Soil Conservation and Drainage Department in the ministry of agriculture is combating land degradation by implementing new management, applying new methods (such as: No Till and Plant Cover) and promoting the use of advanced engineering tools.

## **Building Economic Resilience in the Drylands**

### ***Enhancing livelihoods through climate change adaptation: Challenges and lessons from practices of smallholder farmers in Ghana***

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Using Enhancing Livelihoods through Climate Change Adaptation and Learning Project (ELCAP) as a case study, this paper explores the sustainability of climate change resilient livelihood practices and adaptation in the Guinea-Savannah agro-ecological regions Ghana. The study draws on theories of climate justice that calls for responsibility to invest in pro-poor resilience in environments where the negative impacts climatic variability and desertification stresses the livelihoods support systems. The study triangulated various qualitative data collection methods including field visits, community meetings, interviews and Focus Group Discussions, informal discussions with professionals, and observations. The findings of the study shows the relevance and importance of adaptation strategies and practices being implemented under *Enhancing Livelihoods through Climate Change Adaptation Project (ELCAP)* project, but could not conclusively agree on the effectiveness of those strategies when the outcomes of a four year pilot project achievements were correlated against long term impacts of climatic variability. The paper calls for strategic investments into livelihood diversification initiatives that focus on the attainment of food security and sovereignty. It also argues for the need for close collaborations between NGOs and Scientific organisations as well as linking incentives to the adaptation of resilient practices so as to encourage early adoption of sustainable livelihood diversification strategies. The study recommends the need to incorporate programs such as crop and weather insurance and the extension of the ELCAP pilot to span at least ten years. The study further argues that to ensure the sustainability of climate change adaptation programs in project that seeks to enhance the resilience of livelihoods and local economic activities within the Guinea Savannah region of Ghana and West Africa, it is important to incorporate programs on Disaster Risk Reduction (DRR), after-harvest loss management of crops and agriculture extension services.

### ***The Economics of Land Degradation –An Initiative for Improving Land Use Management and Promote Resilient Economic Development***

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Land Degradation and desertification substantially reduce the flow of land and soil related ecosystem services (ESS) in drylands, thereby constraining local development, reducing food security and triggering resource conflicts. Although the biophysical process and economic impacts are increasingly understood, global and regional efforts to combat land degradation fail to prevent the further loss of land, whose economic dimension is estimated at 40 billion USD/year. The losses on a global scale are likely to be felt at the regional and local scale and severely hinder the further economic developments of drylands, which represent the livelihood of ~35% of the world's population. The integration of the economic perspective into the management of dry-and arid lands is directly related to the maintenance of biodiversity and calling for the integration of sustainable land use management (SLM) practices. The Economics of Land Degradation (ELD-) Initiative therefore strives to highlight the economic dimension of the destruction of soils on a global level and promote approaches to include scientific insights into decision making. A stepwise approach been developed to estimate the economic benefits and costs of action during the first six steps, and suggests the subsequent implementation through different tools within an additional one. It thereby facilitates the recognition of economic benefits derived from SLM and therefore contributes directly to reducing the economic losses from desertification. Within these steps, drivers for unsustainable land management and their impact are being addressed as well as possible pathways for different stakeholders to achieve a more sustainable utilization regime of available land resources and improving the local or regional socio-economy. The identification of alternative development options does not only facilitate the diversification of livelihoods, but also supports to counteract path-dependency. Both processes are necessary preconditions for economic resilience. Ultimately, the economic sphere must be included into considerations regarding the interlinkage between environmental processes and the impact of human activities.

Approaching the global scientific community, decision makers and stakeholders from the private sector individually secures that each target group is provided with specifically tailored insights, methodologies and recommendations. Through the established network of ELD-partners, it is secured that discussions and outcomes will be integrated into future actions and a dialogue between the target group spheres is initiated. Through consultative and participatory

processes, different stakeholder groups are integrated within the assessment and consecutive implementation pathways. This links the levels within the panarchy of the micro- and macro-economies and supports efforts to reduce the economic impact of land degradation as well as reducing the system's vulnerability.

The established working groups under the leadership of renowned and interdisciplinary researchers focus on (a) future scenarios of land degradation process (b) data and methodology and (c) options and pathways for action. All three working groups will feed their results into the outreach structures towards the respective three target groups and therefore contribute to a sound knowledge base for application of SLM-measures.

Thus, the ELD-Initiative functions as a link and catalyst between stakeholders from the field of science, the policy and the private sector to increase the economic resilience on all scales. This is regarded as crucial for a holistic approach to encounter the global threat of degrading land and broaden the focus of land degradation related activities by including economic rationality and argumentation.

### ***A new perspective on the various constraints to participation of sub-groups from the same ethnic minority in a formal business economy: The case of Israeli Negev Bedouin***

**Miri Arbiv**, Ben Gurion University of the Negev; Israel

**Purpose** – In order to increase participation of ethnic minorities in a formal economy, the purpose of this study is to examine whether there are internal sub-groups that are faced with more constraints to develop business activities leading them to participate in an informal economy.

**Design/methodology/approach** – A questionnaire examined potential correlations between coping methods of existing constraints to small business development and participation in an informal economy, was completed by 281 small business owners from the same ethnic minority. The comparison was based mainly on personal background and business characteristics. For more information, we conducted semi-structured interviews with 22 Bedouin small business owners.

**Findings** – Current research indicates that small businesses owners who belong to different sub-groups in the same ethnic minority are faced with varied constraints to small business development which lead part of them to different business formulation orientation. Findings also indicate that each constraint is derived not only from shortage of physical resources but also from socio-cultural factors. However, our results indicate that each sub group requires a different policy approach.

**Originality/value** – Current research demonstrates that participation in an informal business economy isn't necessarily a personal choice to earn more money, to avoid taxes or general policy but might be a result of internal market failure. In order to increase ethnic minorities' impact on formal economy and on regional economy development, this study highlighted that appropriate public policy intervention is needed. Based on these results, we suggested some relevant policy options.

## **Carbon Footprint**

### ***Buildings and Carbon Emissions: Sources and Sustainable Solutions for Reduction***

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The imperative to reduce atmospheric carbon is well documented. One significant area of production is from the built environment; which is responsible for up to 40% of global energy consumption and 30% of the world's carbon emissions (UNEP, 2009). Not only is this carbon produced from the operation of buildings and associated infrastructure, research indicates that a significant proportion of carbon is produced during the process of construction and from the production of the building materials themselves; the embodied energy. In addition, transport, water and



waste services are also responsible for substantially increasing the carbon produced. To reduce the carbon footprint of a building, a precinct or wider, measurement must be assessed before undertaking appropriate reduction management. This paper outlines the problem, posits a conceptual model for carbon reduction, showcases a life-cycle analysis case study for group housing carbon foot-printing, and details an emission reduction strategy. The whole process has been termed LEVI© - Low Energy Village Infrastructure. LEVI accounts for a well-defined series of inputs which make up the carbon footprint, the embodied and operational energy of the village, then applies the constraints and influences bearing on the calculation, and finally, builds a scenario of sustainable solutions to reduce the footprint to a point of carbon neutrality. With specific reference to the case study of a mine site village. It was found, that the carbon footprint of this typical 162 resident fly-in/fly-out mine site village worker was 2,600 tonnes CO<sub>2</sub>-e over an anticipated village life of 5 years and 1,826 tonnes CO<sub>2</sub>-e over a 20 year lifespan. This equates to 16 and 11 tonnes CO<sub>2</sub>-e for each resident worker, which is twice a single Australian resident's footprint (Gov. of WA., 2008, ABS, 2012).

### ***Remote Indigenous community water management and related carbon impacts***

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The transition to a low carbon economy provides potential opportunities for Indigenous communities living in remote areas of Australia. Recent studies and trial projects indicate a potential range of benefits from early season fire management, biosequestration, bioenergy production, renewable energy systems and energy monitoring services. Remote Indigenous communities in Australia typically have few employment opportunities; and the health and socio-economic statistics of residents indicate several disadvantages compared to the average non-Indigenous Australian. Despite this, many communities maintain a strong culture and a wealth of traditional knowledge; particularly, in relation to natural resource management. Longitudinal studies also reveal the health and social benefits of small communities living traditional and active lifestyles.

The carbon profile of communities is highly influenced by their dependency on external factors such as: energy, housing, food and general service supplies and lack of internal resources. An engagement model was designed and tested with remote community residents to empower them in deciding and selecting carbon mitigation programs suitable for their community assets and goals. The model investigated carbon emission reduction strategies for six key sources including: materials, construction processes, stationary energy, transport, water and waste systems.

This paper provides background information on water management and utilisation initiatives selected by the research participants and consequently, the modelled results of their implementation on carbon management. The water management initiatives include: water efficient appliances; recycling of water via evapotranspiration trenches and constructed wetlands for garden use and to provide cooling landscapes around housing; green wall structures on housing to further promote energy efficient interiors; and permaculture gardens for local food production which reduces transport related emissions.

### ***Rapid mitigation of global warming by dryland rehabilitation: a win-win development strategy for marginal dryland areas***

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Small scale biogas digesters have been used throughout the world for converting organic materials to biogas. Household or community scale digesters for food and other organic wastes could play an important role in remote and desert communities, because the biogas can be used for cooking and heating purposes. This can substitute other fuel that needs to be imported. Environmentally, the benefit is twofold. Firstly, if the waste is disposed improperly or simply landfilled, the resulting fugitive methane contributes to greenhouse gas. Secondly, if wood is used as fuel, vegetation in desert environment can be depleted; hence, degrading the environment.

The performance of small scale digesters, particularly household digesters, has not been thoroughly studied despite the millions that have been used worldwide. Notwithstanding - many failures, small scale digesters appear to operate satisfactorily, even if not under optimum conditions. Recent study by Murdoch University researchers\* show that it is

feasible to model the performance of small scale digesters based on the fundamental study of kinetics of anaerobic conversion of organic waste to methane. The paper summarises our understanding of the process and performance of small scale digesters; particularly for food waste. Despite the complex series of processes from hydrolysis of the organic components of the food waste (lipids, carbohydrates, proteins), their conversion to volatile fatty acids and to methane gas and because of the generally long residence time in the digester, surprisingly, a simple first order kinetic model can be used.

The model can be used to predict digester performance, guide designers of small scale digesters and assist users on how to obtain the best performance of an existing digester.

### ***Onsite carbon and nutrients recovery from dairy manure waste in a rural desert farm by hybrid hydrothermal carbonization and gas biofiltration***

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Waste management from remote decentralized farms, such as those in the Israeli Negev desert, is a global challenge due to costly waste transportation, difficulties in treatment and disposal. Therefore, decentralized solutions are required. This project focuses on developing a new technology for dairy manure waste management that combines hydrothermal carbonization (HTC) in supercritical water for bio-coal (energy) production, followed by aerobic biofiltration of the HTC-gasses and liquid effluent for nutrients recovery. Manure waste samples from the Tenne dairy farm that grows 250 cows and produces four tons of manure-waste per day, was collected routinely. The raw manure-waste was analyzed for organic matter, carbon, caloric value and nutrients (N-P-K). Subsamples of the waste were then carbonized under various hydrothermal conditions (e.g. in 250 °C, 5 MPa for 2 h); followed by characterization of the carbonized solids, liquid and emitted gasses. Carbon and nitrogen mass balances, together with the system energetic efficiency, was tested. For example, the energy required to heat a kg of dairy manure-waste by HTC reaction ranges between 2-3 MJ, while the energy in the produced bio-coal was found to be ~20 MJ, suggesting significant net energy gain. Most of the organic carbon solidified (40-50% C) and the HTC aqueous effluent contained fairly low concentrations of dissolved organic carbon (~1% C). Analyses of the aqueous product revealed significant nutrient concentrations ranging between 1,500-2,000 mg N L<sup>-1</sup> and 2,000-2,500 mg K L<sup>-1</sup>. Gas analyses from the HTC demonstrated some emissions of greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O), as well as, higher concentrations of ammonia (~7,500 ppmv) and hydrogen sulfide (~1,000 ppmv). Therefore, biofiltration of the hydrothermal gas streams seems to be feasible in order to maximize the recoverable fraction of nitrogen and to reduce gas pollution. The suggested scheme is expected to: (a) extract and transform most of the manure organic C into a valuable coal-like energy source, (b) recover most of organic N as ammonium/nitrate rich liquid fertilizer and (c) reduce the amount of greenhouse gas emissions often associated with dairy waste treatment.

### ***Integrating anaerobic manure digestion with algal cultivation for decentralized near-zero discharge waste management***

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In dry lands such as the Negev, goats are grown in large numbers, producing large amounts of manure, which may cause detrimental effects to the environment if not properly treated. One possible treatment for this waste is anaerobic digestion which is expected to reduce the potential pollution load of the manure and produce biogas that can be combusted for production of renewable energy. Byproducts of the process are stabilized solid waste and fairly high volume (x6 of manure) N-rich saline effluents, which are often released to the environment (or reused for agriculture) and despite their potential fertilization properties, might still be a source of contamination (i.e. salts, pathogens, micro-pollutants). Moreover, the combustion of biogas also produces greenhouse gases as NO<sub>x</sub>, sulfide and CO<sub>2</sub> as

byproducts. The goal of this research is to reduce the environmental risks associated with anaerobic digestion output by pairing it with cultivation of microalgae, used as “polishing” treatment for the effluent and the exhaust gases. The algae can be harvested and may be used for various purposes. The supernatant (effluent) from the anaerobic digester provides a nutrient-rich, natural, low-cost substrate for cultivation of marine/saline algae species. Furthermore, the polluting biogas combustion products, composed partly of CO<sub>2</sub>, can serve as a carbon source for the algae that have nutritional demands of C:N ratio near 30 for production of oil-rich biomass. Initially, a 6m<sup>3</sup> anaerobic digester was constructed and fed routinely with goat manure (~50 kg wk<sup>-1</sup>) and paper waste (~2 kg wk<sup>-1</sup>). Mesophilic conditions (13.60C- 27.40C) inside the reactor were achieved by using a solar-heated boiler. Carbon and nitrogen mass balances are conducted to test the digester efficiency, and suitability of the supernatant and combusted gas as an input for algal culture.

Goat manure contained 35.2% carbon and 1.58% N (C:N ratio of 22.1), which was increased to 30 by addition of paper waste. The biogas was composed of 60-70% methane, > 30% CO<sub>2</sub> and <1% other gasses such as sulfides and NO<sub>x</sub>. The effluent contained about 200 mg/L N and 40.54 mg/L P. These results demonstrate the potential of the digestion output to satisfy the requirements of micro-algal cultures. We will present a detailed analysis of the system including first data on algal cultures fed with biogas derived substrates.

## Climate Change

### *Fluctuation in precipitation levels and out of ordinary rain events in the Southern Arava Valley 1949-2014*

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The Extreme arid zone of the Southern Arava Valley has a recorded average of precipitation of 20 mm a year. Rainfall data was examined annually as measurements of 27 - 64 years in several sites in the region from 1951 - 2014.

Moving averages and trend lines were plotted for each site and for the years 1993-2014 showed declining precipitation over time of more than 50%. Floods during these years appear to be very rare. These dry years caused high mortality rates of acacia trees and desiccation of springs.

Since 2010 the trend was changed. Three from the last five years were very rainy (compared to the average). On 17-18.1.2010 extreme regional rain event was in the whole Negev, Arava valley and Sinai. Three rain events from February to April dropped high amount of rain in most of the region and floods in most of the streams.

In autumn and winter of 2012-2013 there were 10 rainy events within a period of 6 months! Since the beginning of data collection in 1949 there has not been a year with as many rainy events as this. During one of these events record discharge was measured in Amram River on November 18, 2012 (27 mm precipitation in less than an hour, flood level of 1.4 m, and a discharge of 77 m<sup>3</sup>/s!!).

An extremely unusual rain event occurred in Israel on May 8, 2014. The source of the event was a Red Sea trough along with a low pressure system north-east of Israel and a high altitude trough. In the Southern Negev, abnormally high precipitation levels were recorded with rainfall anomalies of tens of mm and a peak amount of 50 mm recorded in the Eilat Mountains. The yearly amount in these sites was 111 - a peak that was never recorded in this region. The last two rainy years were followed by a significant improvement of the ecological system which was on the verge of collapse.

One of the most interesting questions is: are the changes in rain distribution and quantity and the extreme rain events caused by ongoing global climate change? To answer this question constant monitoring and specific measurements of precipitation and flood events must continue.

### *Connecting climate change and surface water flows to aquifer recharge and groundwater management*

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Planning to meet water demands in semi-arid regions is particularly challenging for groundwater dependent communities where aquifers are being replenished by intermittent streamflow events. Projected and observed climatic changes for the Southwestern United States (U.S.) increase uncertainties. This project, which is funded by the U.S. National Oceanic and Atmospheric Administration employs a novel modeling framework and extensive stakeholder interactions to achieve the following three objectives: (1) Address climate uncertainties with a sophisticated modeling framework; (2) Increase stakeholder capacity to adapt water planning and management to future climate uncertainties; and (3) Establish the transferability of the modeling framework and capacity building approach.

On the international border between the U.S. and Mexico, the city of Nogales, Arizona, and surrounding communities rely on water resources from a relatively shallow regional aquifer. Highly variable seasonal flow events on the Upper Santa Cruz River are the main source of recharge to this aquifer and create a tightly linked relationship between localized aquifer conditions, streamflow variability, and regional climate patterns. Recognizing the interrelated hydrologic conditions, the Arizona Legislature formed the Santa Cruz Active Management Area in with a two-part statutory management goal: a) Maintain a safe-yield condition in the active management area; and b) Prevent local water tables from experiencing long term declines.

To assist it in developing an understanding of regional aquifer conditions, The Arizona Department of Water Resources created a model depicting localized and regional hydrologic conditions and interactions between surface flows and aquifer conditions. The project team has been working with highly interested and knowledgeable stakeholders to incorporate greater climatic uncertainty, along with the concomitant uncertainty in the recharge of shallow basins upon with the City of Nogales, Arizona water utility depends, in the region's water planning and management. Through extensive work with stakeholders and agency personnel, this effort explores how groundwater management efforts, specifically the assured water supply program, can incorporate climate science/climate change information and surface water-groundwater connectivity. The authors will present the scientific and stakeholder engagement methodologies and results and will include discussion of the results of workshops held elsewhere in Arizona to explore the transferability of these methodologies. Through this presentation, the authors hope to obtain additional input on transferability potential.

### ***Climate Change and its Uncertainty in Drylands of Kachchh, Gujarat, India***

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It was rightly pointed out that climate change has long-since ceased to be a scientific curiosity, and is a growing crisis with economic, health and safety, food production, security, and other dimensions (IPCC, 2007). In many countries, poverty is intimately related to repeated exposure to climate risks (UNDP 2007). Shifting weather patterns, for example, threaten food production through increased unpredictability of precipitation, rising sea levels contaminate coastal freshwater reserves and increase the risk of catastrophic flooding, and a warming atmosphere aids the pole ward spread of pests and diseases once limited to the tropics (UNESCO, 2009). Therefore, extreme climate events (i.e., droughts, floods and storms) and inequalities within countries remain as mounting concerns across the world, which will increase the risk of exposure to climatic disasters.

Among the various land forms, drylands are vulnerable to all the vagaries of climate change and are among the world's most variable and highly unpredictable ecosystems, characterized by low, erratic rainfall and high inter-annual climatic variability. Pastoralism, agro-pastoralism and rain-fed agriculture are the dominant land uses and livelihood systems in drylands. Local people have developed the knowledge, experience, institutions and technologies to harness and make use of the variability and uncertainty that permeates dryland ecosystems (Kratli, S., and Schareika, N. 2010).

India encompasses a total dryland area of 228 mha (69% of geographical area). Gujarat State located on the western part of the country encompasses a total area of 19.6 mha, in which 68% falls under drylands. The Kachchh district located on the north-western part of Gujarat alone covers 34% area of drylands of Gujarat. The history of Gujarat encompasses the Indus Valley civilization known as the Harappan civilization existed during the historical time-period from 3300 to 1700 BC. Gujarat State showed a remarkable progress in industrial development since its formation as a separate State in 1960 and ranked first in industrial investment and second in terms of value of production and value addition in industrial sector in the country.

The Government also introduced incentive schemes, from time to time, to promote industries mainly in the under-developed areas of the state to enhance regional imbalances. All these initiatives have made Gujarat as the emerging highly industrialized state in the country today. In the context of industrialization in Gujarat, the need of the hour is to address the environment and industry related issues that are critical for sustainable development. While the human society has to focus on development and progress for all, the challenge is to meet the basic needs and development aspirations even while reducing greenhouse gas emissions and responding to the global issue of 'climate change'. The dynamic change in its climatic patterns was observed since the mid 20th century. Initially, these changes were looked upon as cyclical changes but latter it was explained that the change in climate is abnormal (Hiremath and Shiyani, 2012). Understanding the reality, the Government of Gujarat has initiated a separate department for 'Climate Change' which is first of its kind in India.

Kachchh is historically known for its uncertainty and the phenomenon of climate change adds to existing woes. This article narrates the climate debate in Kachchh district of the Gujarat State from available literature which are synthesized and integrated to understand the existing and emerging climate change consequences and adaptation knowledge in Kachchh. Understanding the likely impacts of climate change is an important foundation for climate change dialogue and adaptation. Information about impacts of climate change is limited and dispersed for Kachchh. Therefore, a collaborative study was initiated by the Gujarat Institute of Desert Ecology, Bhuj-Kachchh with STEPS centre of the Sussex University, UK to understand the effects of climate change and its uncertainties in Kachchh district of the Gujarat State, India. The study has analyzed the secondary data (rainfall, agriculture, livestock, etc.) of over 30 years and primary data on people's perception on climate change from 'below' (villagers) and 'above' (planners, policy makers and scientists).

Intensive study was undertaken in three villages of Kachchh representing three regions and three major ecosystems. The study villages include Kanmer village (Agriculture, located in eastern parts of Kachchh), Banni region (Grassland, located in central part of Kachchh) and Jakhau village (Coastal area located in the western part of Kachchh).

The study highlighted that climate change is expected to affect two major livelihood areas of Kachchh; agriculture and livestock based sustenance. The rural population is predominantly dependent on agriculture, which in turn is highly dependent on the south-west monsoon. A decreasing trend of about 6 to 8% rainfall is observed over eastern Madhya Pradesh and some parts of Gujarat (NAPCC, 2008). Gosain et al., (2006) projected water shortages throughout Kachchh and some parts of Gujarat. Thus, farmers are trying to cope with the shortages in water for agriculture. Due to weather events and other social reasons, there have been a number of changes in agricultural pattern which have made the farmers more vulnerable. The incidence of droughts has become a regular feature: in recent years every 5-year cycle has 2-3 years of drought. About 80 per cent of the population in the Kachchh district depends on rainfall whose recurrent failure renders them increasingly vulnerable to droughts and consequent famines. For poor farmers, adaptation strategies are vital, as failure to adapt could lead to social problems and displacement (Downing et al., 1997). Even two consecutive years of low rainfall make it difficult for the communities to sustain their livelihoods. It becomes worse, when there are 3 consecutive years of low rainfall. Statistical data indicated that in the last two decades, the intensity of the 3 year period of consecutive low rainfall is increasing, thereby creating a severe drought situation (Shaw, 2003). At a larger geographic scale farmers in Gujarat have long faced critical water shortages and scientists view that the climate change is likely to further exacerbate the situation. The intensity and return period of major drought events have been increased substantially in the last two to three decades which is in line with the projected impacts of climate change. Extreme weather conditions in the form of droughts, floods and cyclones have wiped out standing crops and the farmers are left impoverished and helpless.

The agricultural policy of the State to bring in more area under irrigation resulted in promotion of agriculture in Kachchh. Various irrigation schemes like damming of rivers and canal irrigation were promoted, however, the use of groundwater for irrigation has also been increased (GES, 2011). Irrigation in Kachchh is largely ground water dependent and 87% of the total irrigated area depends on the ground water sources and out of which 85% have traditional wells (GES, 2011).

Crop pattern too have undergone perceptible changes in the last the last 24 years. The area under traditional crops of cereal reduced to 13% of the total area under cultivation. However, area under oilseeds was 41%, fodder 16%, vegetables 13% and spices 4%. The area under cash crops has increased at the cost of traditional crops. The increase in fodder cultivation indicates enhanced demand from livestock sector.

During the survey a total of 210 peoples were interviewed through a structured questionnaire. About 53% of the respondents stated that the temperature has increased over the last 30 years. At the same time, 52% of the respondents revealed that the total rainfall has also increased during the recent decades with subsequent decrease in the frequency which led to unpredictable monsoon and crop failures. Due to these, major climate change related impacts visualized in livelihood systems include; agriculture (33 % respondents), Livestock (32% respondents), Fisheries (13%

respondents), Forest (10% respondents), Grassland (8%) and Mangroves (4%).

As a coping strategy, villagers have changed the cropping pattern which is mainly to get more production (28% respondents), impact of rainfall (22%), Market availability (21%), ground water decreasing (18%) and increasing transportation facility (11%) are the major reason. Ground water decreased 70 feet during the last 40 years and the stated reason behind that were increased water salinity (43% respondents), more irrigation (38%) and less rainfall (19%).

Ecology of arid ecosystems like Kachchh cannot be understood in isolation from an understanding of the pastoral society and the management of their livestock. Neither humans nor livestock could survive in arid areas without the other (Joeckes and Pointing, 1991). The total livestock in Kachchh has increased from 94,097 in 1962 to 1,707,279 in 2007, an 18 fold increase in 45 years (GES, 2011).

To look into the trends of livestock composition, the available data on total livestock was grouped into cattle, buffalo, goats and sheep and others (horses, donkeys, camels and mules). In 1962, cattle accounted for major share (49.1%) in the total livestock composition, followed by goat (21.4%), sheep (19.3%) and buffalo which contributed only 8.6%. But in subsequent years, the population of goat and sheep increased in Kachchh, with simultaneous decline in the population of cattle. However, buffalo population increased steadily over the years, after 1977. Rise in sheep and goat population was recorded after 1977 livestock census, coinciding with the drought years of Kachchh for the period 1980-90. Kachchh had regular cycles of drought years and it was easy to maintain sheep and goat, rather than cattle or buffalo. Sheep and goat are ground browsers and can survive on less green cover. Cattle to buffalo ratio in the Kachchh region indicated a declining trend from 5.7 in 1962 to 1.8 in 2007. The changing climate and other anthropogenic factors have affected the fodder availability which in turn has forced to change the livestock composition in the region. The daily requirement of fodder for a buffalo is 10% of its body weight; therefore, increase in buffalo population subsequently enhanced the demands of fodder.

Major factors affecting the fodder availability recorded was; invasion of *Prosopis juliflora* (41% respondents), impact of rainfall (29% respondents), increasing temperature (15% respondents), and increasing land salinity (11% respondents).

Major factors contributing to this change in livestock composition are susceptibility of cattle to *Prosopis juliflora* and decline in grazing land (29% respondents), promotion of dairy industry (29%), due to transportation facility (17%), impact of temperature on milk yield (15%), droughts (6%) and less inclination towards pastoralism by younger generation (4%).

At this juncture, it is important to strengthen the locally appropriate livelihood options (e.g. pastoralism, dryland farming) through innovative planning and implementations.

### ***Erosion control, restoring soil fertility and agro-economic valorization of degraded land by inclusive watershed management: The case of South West of Burkina Faso***

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Climate change poses a serious threat to the agriculture sector in Burkina Faso. Unadapt land use methods and increasing pressure on suitable land for food production due to the high demographic growth rate (app. 2,5% per anno) and an absence of alternative income source outside the agricultural sector have led to severe degradation of agricultural land and natural resources (e.g. loss of vegetation coverage about 60 % during the last 15 years in the South-West Region of Burkina Faso mainly because of a high demand after fire wood as energy source and for local beer production). The impacts of climate change and resulting climatic irregularities such as poor rainfall patterns in terms of time and location, dry spells and locally spotted extreme precipitation are aggravating the degradation of vegetation and soils. Both, climate and non-climate induces stress factors are influencing the sensitive ecosystems reciprocally. If the vegetation coverage is continuously reduced, than the soil erosion effects thru heavy winds and floods will be increased radically. Consequently the agricultural productivity as the main economic income basis will be heavily effected with unforeseen socio-economic concerns for the rural population (e.g. increasing of hunger periods, migration to urban areas or neighbor countries or by destroying the potential fertile production areas by switching to other economic activities like gold digging).

The majority of the population (89%) lives in rural areas, is mostly under 20 years old and highly vulnerable without having the capacities to adapt and intensify at the same time their cultivation techniques and farming operations to the impacts of climate change (Berger and Cissé, 2014).

To improve the adaptive capacity of the local population in the South-West of Burkina Faso and to adjust to the impacts of climate change the “Programme Développement de l’Agriculture (PDA)” of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH has been implemented a very successful multi-stakeholder approach, which is financed through the German Energy and Climate Fund (EKF) on behalf of the Federal Ministry for Economic Cooperation and Development (BMZ).

To reduce the local vulnerability the program focuses on carrying out adaptation measures at meso and micro level. At village level, the target group consists of women, men and youth who work in agricultural production and livestock husbandry. At the meso level, the program is working with the municipalities and technical services at provincial and departmental level as well as the employees of local organizations and research institutions that offer services in climate change adaptation. Based on the analysis of the training and advisory needs of the service providers, suitable training modules are carried out. The program helps service providers integrate adaptation measures into their advisory services by providing process support, technical advice and training. Partnerships with research institutions are supporting the further development of adapted species and varieties for agro-silvo-pastoral systems.

The local population is being supported in introducing climate change adaptation measures such as soil and water conservation methods in suitable watersheds of selected communities. Farmers are trained in constructing technical-physical (stone rows, dikes, dams) and biological (planting along stone rows) erosion protection methods. Furthermore their capacities are strengthened to introduce agricultural techniques (adapted seeds, storage facilities to produce compost and irrigations systems like drip irrigation) into their existing cultivation practices, thus adapting their production system to climate change. This will increase, diversify and stabilize yields as well as income therefore improve the resilience of rural households.

Only the involvement and a strong ownership of the local population allows to restore yearly up to 4000 ha degraded land significantly and revalorized it by planting of about 50.000 trees and shrubs like *Moringa oleifera*, *Jatropha curcas* and other species with the potential to create and to diversify long-term income. After a shored period of time the beneficiaries are encouraged to recultivate their soils even with crops which has been abandoned in the past. Recent findings show that implementing the “cordons pierreux method” with additional tree planting along the stone rows accelerates the self-healing process of soils in terms of increased content of organic matter and other bio-chemical parameters (Yaméogo et al. 2013).

The measures also benefit upstream and downstream micro, small and medium-sized entrepreneurs who work in processing and marketing. This creates new jobs, especially those accessible to women and young agropreneurs. The intense participation of all participants in the planning and implementation of measures is a proven concept for strengthening personal initiative and sustainability. Employees of government structures, interest groups, small industry associations and local administrations at various levels (macro, meso, micro) are included through training courses and other support measures of the program like the GIZ value chain approach.

## **Climate History, Drought and Desertification in the Ancient Near East**

### ***Drought, Economic Crisis and Demography: Two Case Studies from the Byzantine and Early Arab Near East***

**Oren Ackerman;** Bar-Ilan University, Israel; orenack@gmail.com

The Near East is exposed to semi-arid to arid climate conditions which are characterized by low water availability and cycles of droughts years. Ancient societies in this area successfully coped with such harsh conditions by several methodologies and adaptations such as utilizing sophisticated agricultural planting cycles, and developing of efficient and sophisticated water harvesting systems. However, long periods of severe drought years during the Byzantine period and the Early Arab period were very harmful for the societies at that time.

Historical evidence indicates that during the Byzantine Period there was a demographic peak in the Near East. Despite this peak, a study of the numismatic finds points to a significant economic crisis in the fifth century CE. Currently available climate and vegetation records indicate that during this period, there was a series of drought years,

characterized by a significant decrease in annual rainfall and a decrease in the amount of olive pollen. An additional series of drought years occurred during the seventh century CE, the period of the Arab conquest of the Near East. It is suggested that the dry climate conditions may have been one of the factors contributing to the demographic decline at this time.

### ***Drought in Jordan: P/PET Classification and Tree Rings***

Sawsan Batarseh<sup>1</sup> and **Hendrik J. Bruins**<sup>2</sup>

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Drought has been defined by the United Nations Convention to Combat Desertification (UNCCD, 1999) in the following way: Drought means the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems. Our research developed a novel approach to classify drought severity in Jordan based on the P/PET index. This research covered a 30 year period from 1976 to 2006 and included 37 meteorological stations distributed across Jordan. Annual time-series analyses were carried out for each station and three drought categories were defined: mild, moderate and severe. We found that the drier southern and eastern parts of Jordan experienced more drought years than the northwestern part of the country. Severe drought years were most frequent during the decade of 1996-2006. The north-western part of Jordan, generally shows a normal distribution pattern, in which mild and moderate droughts are more frequent than severe drought. However, the opposite was noted for the southern and eastern desert stations, where severe drought is most frequent.

The driest hydrological year in the last three decades was 1998/99. Food grains production was negatively affected by the severe drought. The production of wheat in Jordan during the hydrological years 1997/98, 1998/99 and 1999/2000 was 35,974 ton, 9,251 ton and 25,434 ton, respectively, showing the drought impact during 1998/99.

Unlike modern meteorological data, proxy palaeoclimatic indicators usually cannot provide information about individual drought years in the past. However, tree rings are the exception. We will compare our data in terms of the frequency of drought years with data from tree rings from Jordan that go back in time to AD 1600.



### ***Post glacial and Holocene Dead Sea levels as indicators of Near East paleoclimate***

**Revital Bookman**, University of Haifa, Israel; rbookman@univ.haifa.ac.il

The unique physiographic setting of the Dead Sea Basin (DSB) as a terminal lake basin makes it an immense geological archive for the Quaternary climatic history. Lake Lisan and the Dead Sea that occupied the deeper part of the basin during the last glacial interglacial cycle recorded changes in the water balance of its catchment. Their past lake-levels reveal the regional hydrologic variations that represent the Levant paleoclimates. The well exposed sedimentary sequences and drill cores along its shores and within the lake combined with high resolution dating reveal dynamic fluvial and lacustrine depositional environments that were controlled by the fluctuating lake levels. Abrupt arid events in the post-glacial DSB were recorded by significant Lisan lake level declines and massive deposition of evaporites that coincided with times of ice and meltwater discharges into the North Atlantic (Stein et al., 2009). This climatic transition was accompanied by changes in human culture: the collapse of the Natufian culture during the Bolling–Allerod and the rise of the Pre-Pottery Neolithic cultures. The “Neolithic revolution” is possibly connected to the last major salt deposition around the 11–10 kyr cal BP before the commencement of the Holocene. During the early to mid Holocene Dead Sea levels fluctuated between 370 to 425 m below sea level with multiple arid events at ~8.6, 8.2, 4.2, cal kyr BP that appear to coincide with major breaks in the Near East culture (Migowski et al., 2006).

Along the last 4000 years high-stands occurred in the second and first centuries BC and the fourth century AD during the Roman and early Byzantine periods, respectively, in the eleventh and twelfth centuries AD during the Crusader period, and at the end of the nineteenth century. These rises mark a significant change in the annual rainfall in the region, which likely exceeded the instrumentally measured modern average. However, most of the period the lake was below the topographic sill (402 mbsl) separating the northern and southern basins of the Dead Sea and was confined to the deep northern basin. The deepest drop in the lake level culminated during the fifteenth and fourteenth centuries BC. The longest low-stand occurred after the Byzantine period and continued at least until the ninth century AD. This arid period coincided with the entrance of Moslem-Arab tribes into the area during the seventh century AD. The dramatic fall of the Dead Sea level during the twentieth century is primarily artificial and has been caused by the diversion of runoff water, but the magnitude is not exceptional for the late Holocene. Although the past level drops never exceeded the modern artificial drop rates, they do represent extreme arid conditions that occurred frequently over the past several thousand years.

### ***Climate Change and Runoff/Floodwater Capturing Agriculture in the Central Negev: Dating, Temporal and Causal Relationships?***

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The scientific fields of palaeoclimate and climatology on the one hand vis-à-vis archaeology and history on the other can be considered as quite different domains of expertise. “Perhaps we should not be surprised that, in general, climatologists make poor historians and that historians make poor climatologists” (Parry, 1981:319-320). Scientists in the former domain may suggest climate change as a factor in human history, whereas historians and archaeologists may only see political, economic, technological and religious factors. Indeed, a time coincidence between changes in climate and human history is not sufficient by itself, albeit very important, to prove a causal relationship. Climate impact assessment, for example on agriculture, is a necessary next step, after contemporariness between the two domains has been established, to investigate the effect of the climate change on a particular economic activity. The central Negev highlands contain thousands of ancient terrace walls built in dry stream valleys (wadis). These systems caused soil accumulation and prevented erosion, i.e. combating desertification in ancient times! How can we date the ages of these terrace walls and the soils they contain? The terraces were built to capture runoff/floodwater in the desert, in order to enable agriculture. Even today Bedouin sow wheat and barley in a number of ancient terraced

fields in the region and may obtain a reasonable harvest in the desert! How sensitive are these systems to climate change? What is the minimum amount of average annual rainfall for these systems to be viable?

In this paper we will give an overview of dates so far published concerning the ages of these terraced fields, based on circumstantial archaeological evidence, radiocarbon dating and luminescence dating. Subsequently, we will show a compilation of climate history in the Levant and compare it with the time periods for which there is evidence of runoff/floodwater farming. The question will be addressed whether temporal relationships between available climate history and available archaeological data, including scientific dating, about the use of runoff/floodwater farming can be established. Finally, the issue of climate impact assessment will be evaluated. Do we have sufficiently detailed palaeoclimatic data to make such assessments (Bruins, 2012)? Did past climatic changes pass a critical aridity threshold, below which runoff/floodwater farming does not seem viable?

### ***Climatic deterioration during the Middle Bronze Age revealed by subfossil wood from the southern Levant***

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A subfossil tree trunk of *Tamarix* from the Sedom Cave reflects an environmental crisis during the Intermediate Bronze Age, which subsequently killed the tree around 1930 BCE. This period coincides with the largest historic fall of the Dead Sea level, as well as the demise of the large regional urban centers of the 3rd millennium BCE. The environmental crisis may thus explain the archaeological evidence of a shift from an urban to a pastoral culture during the Intermediate Bronze Age. This was apparently the most severe long-term historical drought that affected the region in the mid-late Holocene.

Parts of trees growing on the Mt. Sedom salt diapir, at the southern Dead Sea shore, were swept by runoff into salt caves and subsequently deposited therein, sheltered from surface weathering. A subfossil *Tamarix* tree trunk, found in a remote section of the Sedom Cave was radiocarbon dated to between ~2265 and 1930 BCE. It was sampled at 109 points across the tree rings for carbon and nitrogen isotopes. The Sedom *Tamarix* exhibits a few hundred years of  $^{13}\text{C}$  and  $^{15}\text{N}$  isotopic enrichment, culminating in extremely high  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values. Calibration using modern *Tamarix* stable isotopes in various climatic settings in Israel shows a direct relationship between isotopic enrichment and climate deterioration, particularly rainfall decrease.

### ***Climate Change, Human action and Desertification in the Wadi Faynan, Jordan***

**Chris Hunt**, Liverpool John Moores University, UK; c.hunt@qub.ac.uk

The Wadi Faynan, at the margins of the Wadi Arabah in southwest Jordan, presently presents a bleak, desertic aspect to the visitor. Yet between the Bronze Age and Byzantine period it was one of the economic powerhouses of the Middle East, with a huge copper-extraction industry and before that it had Neolithic rainfed agriculture. Evidently, the Faynan region has become “desertified”.

The surviving evidence is often patchy in both space and time, and further interpretation is hampered by the comparative absence of quantitative information on past and present landscape processes and human activities. Systems-based analysis emphasises the complexity in scale and intensity of climate-environmental-human interactions. Relationships have been found between variations in precipitation, vegetation and geomorphic regime between 11,000 and 6,000 years ago, and from about 1,000 years ago to the present day. Between 6,000 and 1,000 years ago, copper mining and metallurgy, initially local in scale, reached industrial scale in Iron Age and Classical times as part of the Imperial Roman – Byzantine economy, followed by sudden collapse 1350 years ago. Industrial development was accompanied by the gathering of water from springs and runoff, and irrigated agriculture. The metal extraction has left a significant legacy of pollution and landscape degradation for later inhabitants of the Wadi. Progressive, probably stepwise, aridification and vegetation degradation started ~7,200 years ago, under the impacts of both human activity and climate change and reached an apogee during the Roman humid period and again during the hyper-aridity of the Little Ice Age. In the former, degradation was largely the result of grazing and fuelwood extraction, while in the latter it was largely climatic in origin. The palaeoenvironmental evidence points to ecological resilience, even during periods of severe human impact or aridity, the steppic vegetation of the wadi persisted. In global terms, the precise mechanisms and history that dominate the “desertification” in the Wadi Faynan may be

unique, but they also point to the profound, long-term and continuing influences upon modern arid lands of events and processes that took place thousands of years ago – and this may have resonance elsewhere.

***A rapid landscape change in 6th century northern Jordan: desertification, or driven by climatic extremes?***

**Bernhard Lucke**, FAU Erlangen-Nuremberg, Institute of Geography, Germany; bernhard.lucke@fu.de

Many areas in the Levant appear today affected by soil degradation, which is usually considered the result of long-term farming since the Neolithic. But also the ruins of the rich cities of antiquity led to assumption that the agricultural productivity of the region was somehow degraded since the abandonment of these sites. European travel reports of the 19th century and excavations in Jordan created the impression that population numbers were strongly reduced during the Islamic periods, leading to 'empty' lands which were only resettled during the early 20th century. However, our case study near the ancient site Abila of the Decapolis in northern Jordan found that the land was probably never 'empty' and always fertile – but valley fills provide evidence for a rapid and intense landscape change during the Late Byzantine period. This was probably caused by a significant shift to aridity which also triggered socio-economic changes of subsistence strategies from agriculture to pastoralism. The dates of sediments which are available so far indicate that the climatic change seemingly occurred rapidly within approximately 100 years during the late 6th and early 7th century AD, and rubble layers show high  $\epsilon$  that it was associated with frequent heavy rainfall events. It might have been caused or triggered by a global climate event creating the "year without sun" or 'Mystery Veil' which the Byzantine historian Procopius described in the year 536 AD. If similar events repeat under the current climate change, it will be difficult to mitigate them.

***Israel Antiquities Authority, “Man-made desertification? The new evidence from a late Neolithic-Chalcolithic occupation of Har Harif (Central Negev highlands, Israel)***

**Jacob Vardi**, Israel Antiquities Authority, Israel; kobivardi@gmail.com

Man-made desertification? The new evidence from a late Neolithic-Chalcolithic occupation of Har Harif (Central Negev highlands, Israel).

During 2012 a series of salvage excavations was held prior to the construction of the new fence along the international Israel-Egypt border. One of the prehistoric occupations that were discovered in the environs of Har Harif is a multi-layered site whose two earlier phases are dated to the late 6th millennium and early to middle 5th millennium BC cal, based on indicative lithics and radiocarbon dates.

The excavations revealed a large compound that was built in a narrow gorge on a south western slope of Har Harif. The architectural remains include an elongated enclosure wall, a pen and habitation units. This architectural pattern accords well with the integration of the pastoral subsistence economy. The finds from the site testify for diverse activities that were carried by the site inhabitants. The excavation yielded a unique find which is not common to the Neolithic-Chalcolithic horizon in the arid environment – dozens of polished flint axes. These tools are typical to Neolithic assemblages retrieved from the Mediterranean regions of the Levant where they are usually related mainly to wood cutting/wood working. Axes are rare or in most cases entirely absent from sites that are situated in the arid regions of the southern Levant.

Samples of charcoal were picked from hearths that were exposed during the dig. A preliminary observation on a sample of charcoals revealed that these originate from Junipers (*Juniperus phoenicea*). The closest living Phoenician Juniper trees exist today at Gebel Helal in Sinai and in Southern Jordan. The identification of Juniper at the 5th millennium phase at Har Harif is significant, since today Junipers are entirely absent from the Negev highlands. Charcoals from earlier Epipaleolithic sites in the environs of Har Harif belong to other sp. That might suggest a deterministic choice of plant use during the Late Neolithic or a change in the composition of the flora which dictated the use of other more frequent sp.

In this paper we suggest that the use of the natural resources by the Har Harif inhabitants during the middle Holocene (roughly 6th- 5th millennium BC), as reflected in the material culture derived from the excavations, might have generated pressure on the local environment leading to the total extinction of the genus *Juniperus phoenicea* from the Negev Highlands.

## Community and Technology in Project Wadi Attir, Workshop

Project Wadi Attir is a groundbreaking initiative of the Bedouin community in the Negev, for establishing a model sustainable agricultural operation. The project was initiated by The Sustainability Laboratory, a US-based non-profit, and the Hura Municipal Council, the governing body of a local Bedouin township. Designed to leverage Bedouin traditional values, aspirations, know-how and experience with modern-day science and cutting edge technologies, Project Wadi Attir showcases implementation of holistic sustainability principles developed by The Lab. It demonstrates an approach to sustainable development in an arid environment, valid and replicable locally as well as in other similar regions around the world.

This session will underscore the significance of the project to the Bedouin Community and will offer a close review of some of the green technology innovations which characterize the project with emphasis on green buildings; soil enhancement; and the project's "waste into resources approach." It will allow for open discussion with the audience about the project and its universal significance.

Moderator: Dr. Michael Ben-Eli, The Sustainability Laboratory

Panelists: Dr. Mohammed Alnabari, Mayor of Hura; Yones Nabari, Founding Member Project Wadi Attir; Nizar Egbaria, Director, Visitor Training and Educational Center, Project Wadi Attir; Prof. Amit Gross, BIDR; Dr. Stefan Leu, BIDR. Dr. Or Yogev, AugWind Ltd.

## Cook Workshop Sessions

### *Sustaining Residential Gardens in Arid Regions with Integrated Lot-Scale Water Systems*

**Josh Byrne**, Murdoch University, Australia

Water use in residential gardens typically comprises between 30-50% of domestic mains water consumption in Australian cities. Drought conditions experienced in the southern and eastern regions of Australia in the last decade led to the introduction of water restrictions in most capital cities as well as many regional towns. In response there has been an increased uptake of external house water conservation technologies and practices including greywater reuse, rainwater harvesting, and efficient irrigation equipment. It can be assumed that the greatest potential for water use efficiency will be achieved when there is an integrated approach to the design and operation of these technologies, however, a review of the literature indicates that the effectiveness of mains water savings through such an approach is poorly quantified.

This paper presents the results of a detailed study of a productive residential garden in Fremantle, Western Australia, which incorporates industry best-practice greywater reuse, rainwater harvesting, and efficient irrigation practices. Monitoring of the watering systems was undertaken to investigate the performance of these technologies when integrated in a holistic systems based approach.

The monitoring allowed for detailed data analysis of property water use and wastewater generation by individual streams as well as rainwater harvesting and soil moisture volumes across discrete hydrozones on a daily time-step basis. The sampling program provides a unique and comprehensive overview of the interrelationship between in-house water use patterns and the dynamics of greywater generation and plant water demand, as well as the performance of rainwater harvesting systems and drip irrigation and the energy requirements involved in their operation.

Findings demonstrate that typical household mains water use can be reduced by around 40% through the incorporation of effective greywater reuse and rainwater harvesting, whilst still sustaining a healthy and productive garden, which would otherwise not be possible under water restrictions where the use of irrigation is limited. These results demonstrate the viability and effectiveness of lot-scale water technologies and their potential contribution to water conservation programs when properly integrated with a carefully planned landscape design.

### ***A multifunctional energy retrofit façade system for different climates***

**Guedi Capeluto**, and Carlos Ochoa, Faculty of Architecture and Town Planning, Technion Israel Institute of Technology, Israel, [arguedi@technion.ac.il](mailto:arguedi@technion.ac.il)

The vast majority of the existing European residential building stock needs energy upgrading to comply with present regulations, reduce consumption and emissions, as well as to improve comfort conditions. Current refurbishment methods are unsuitable to obtain short-term results. Façade retrofitting provides a good solution as residential envelopes account for 20-30% of total building energy consumption. However, common prefabricated systems based mostly on improved insulation do not adapt to every situation and extreme climates.

The European Union FP7 project MEEFS has the objective of developing modular façade retrofit systems that achieve comfort and energy efficiency, while addressing the shortcomings mentioned above. We present here the methodology to determine suitable climatic design strategies for each project location, through diverse technologies that can be supported on a modular construction system.

The methodology had three stages:

First, climate characteristics for the European continent were examined for common trends using the Köppen climate classification. Representative cities were chosen for each climate zone. In parallel, data from previous EU projects was used to characterize the existing residential building stock, such as U-values for external walls and windows. Project partners collected and determined information for façade features and dimensions in the representative cities. These elements were used to assemble a basecase typical building and apartment unit for computer simulation in each location.

Second, strategies for each climate were determined based on the psychometric chart for human comfort. These were: glazing type, insulation, shading, ventilation and façade albedo. Based on cost and structural feasibility, ten strategy combinations were also studied.

For the third stage, energy consumption from applying each strategy and their combinations on the basecase were calculated and analysed for the representative cities.

As a result of this methodology, strategies were ranked for energy use and presented in an easy to use graphical form. Potential technologies that fulfil the strategies were identified. These will be incorporated into the prefabricated modules according to a cost optimization analysis. The strategy selection method will be abstracted into a computer tool.

### ***Recommendation for daylighting in sunny regions***

**Eran Kaftan** and Evyatar Erell, Ben-Gurion University of the Negev, Israel; [eran@recod.net](mailto:eran@recod.net)

Large glass facades, currently a popular architectural feature, do not ensure better use of daylight as is often suggested. In fact, excessive glazing may create glare hazards, especially in sunny regions. As a result, we often see windows that are permanently obstructed by closed blinds or opaque curtains, with electric lights switched on even during the daytime. The presentation will describe three types of recommendations for architects to address this problem: prescriptive, performance and methodological. The first, a prescriptive list of recommended features of shading and daylight systems, and the second, performance requirements for visual comfort, are often integrated into daylighting standards, some of which may be mandatory. However, from the architect's point of view, neither prescriptive recommendations nor performance requirements sufficient guidance, since they do not teach how to design optimized or unique solutions. Innovative and highly effective design may require a modified version of academic or applied research methodologies, adapted to accommodate the unique needs of architectural practice. Since its scope and objectives are substantially different from those of academic or applied research, the term Practical-Research was proposed for such an investigation. Practical-Research is a systematic inquiry designed to generate missing valuable information to the design team, to improve a particular project. In order to take full advantage of such a research, a conceptual model for integrating Practical-Research in the architectural design process was suggested. The model organizes the tasks required for effective design of expert fields (such as daylighting), according to the major design phases and the required expertise: architectural design, expert consultation, and Practical-Research.

### ***Implementing energy efficiency measures for buildings in extreme climatic conditions***

**Agis Papadopoulos**, Aristotle University, Thessaloniki, Greece, agis@eng.auth.gr

The implementation of energy efficiency measures as well as the integration of renewable energy systems, on the move towards the Zero (or Nearly Zero) Energy Building is certainly a challenging task. This is even more the case, when buildings are to operate in extreme climatic conditions, especially with respect to the cooling demand, as it happens in the Eastern Mediterranean, the Middle East and North Africa.

Energy conscious architectural design is a pre-requisite, as well as the utilization of the building envelope's thermal properties. But even in the most successful passive buildings, the use of renewable energy systems, as an integral part of the building's design, is needed in order to achieve Zero energy status. Systems like active solar thermal and geothermal ones can provide the necessary heating and cooling, whilst building integrated PVs can cover the electrical loads, either in terms of consumption or of expenses.

In any case, all those systems have to be fitted smoothly into the thermodynamic profile of the building's envelope and operation, implying the use of advanced controls and automation systems, as the optimum combination of all this "hardware" is rather difficult to achieve by using "traditional" controls. Finally, understanding the requirements of the user and providing adequate solutions remains the single most important prerequisite, if the design had to be successful and just a simple academic exercise.

Those points will be addressed within this paper, on the base of some successful examples of energy efficient buildings, with well integrated energy conservation and utilization systems, but also of some rather unsuccessful ones, as both cases can lead to useful conclusions.

### ***Green house construction***

**Maria and Walter von Roth**, UANL, Mexico, mrechy\_1940@hotmail.co.uk

The subject structure consists of a prototype house with plan dimensions of 8 m x 4 m. A variety of materials were employed in its construction, with special emphasis being placed on using environmentally friendly non-toxic materials. The structure's core consisted of reinforced concrete frames with masonry infill walls with locally sourced materials. Inside faces of the walls and the roof's outer face were covered with proprietary composite panels, which are manufactured with a mixture of cement, volcanic ash, and local sawmill waste. These panels were analyzed for their physical and chemical properties, as well as for their resistance to decay and insects when subjected to extreme conditions for 15 years. The panels have also shown to provide thermal insulation and are non-combustible when in direct contact with fire. The roof surface was further covered with a blend of local drought-resistant succulents and cacti. The presentation consists of a detailed review of the construction process and materials employed.

### ***Passive and low energy architecture: the Israeli approach within the sustainable building standard***

**Edna Shaviv**, Faculty of Architecture and Town Planning, Technion Israel Institute of Technology, Israel, eshaviv@technion.ac.il

Current environmental assessment methods commonly use a simple 'point hunting' approach. As a result, developers and design teams try to obtain "cheap and easy points". Consequently, they avoid choosing "Energy points". Additionally, "Energy points" are mainly achieved by improving the mechanical, electrical and hot water systems, since they are easier points to handle than designing low energy buildings, especially at the advanced design stages. This is in contrast with the fact that buildings are designed to last 50 to 100 years and the mechanical systems only 15 to 20 years, at most.

The new Israeli "Sustainable Building (Green Building) Standard SI5281" attempts to overcome the deficiencies presented above by dividing the energy chapter into two parts; "Building energy performance" and "Building services systems". Moreover, it tries to make the "Building performance points" easier to handle at the early design stages by using simple CAD tools for the performance based method, as well as providing simple design guidelines for the prescriptive-based method.

The paper presents the criteria and rules that the Israeli Green Building standard applied in order to guarantee that green buildings will save energy and in order to avoid the faults of present situation that the minimum required points for energy saving may be achieved with no need to design the building as a low energy one. Emphasis will be put on the sections concerned with the architecture of the building, the requirements of which are based on simulations and modelling, as presented in the Appendixes to the Israeli Green Building Code, written by the author.

This includes:

- a. The determination of the Bioclimatic and Passive solar strategies and their implementation, as well as quantitative reviewing.
- b. Design for minimal energy consumption for cooling, heating and lighting, due to the optimal design of the building geometry, orientation and envelope materials.
- c. Requirements for solar and wind rights, as well as proper shading and natural ventilation, for the proposed building and the close surrounding environment: buildings and open spaces.

### ***Application of sustainable building and operating technologies in residential units – cost and benefit***

**Shulamith Gertel**, Ministry of Housing, Israel, shulamitg@moch.gov.il

Israeli Government Ministries of Construction & Housing and Energy & Water have collaborated to conduct a study aimed at formulating a series of economic mechanisms to encourage application of sustainable building and operating technologies in residential units. This research is intended to create avenues for promoting home affordability, reduced household expenses and improved thermal comfort. A first time Israeli techno - economic analysis is devised, using IESVE software, to quantifying potential savings in household expenses resulting from installation of energy and water saving devices. Cost-benefit calculation of sustainable upgrade costs in relation to the scope of potential savings in household operating expenses is applied to different dwellings types with various exposures to climate. Potential monetary savings measured in relation to sustainable technology applications are represented in terms of reduced percentages of average operating expenses. Successful economic models adapted to Israeli conditions for funding sustainable upgrades are expected to show an average return on installation costs within 7.75 years. Analyses compare costs and savings of installing technological devices separately, and as "technological packages" combining devices to promote optimal performance at a lower cost. Potential for savings in home maintenance costs is indicated in relation to education and information operating technologies, sealing and insulation, heating solutions and acclimatization / air conditioning systems. Research conveys the need for economic mechanisms to target particular beneficiaries such as socio-economically weak households, and large households who tend to average higher than ordinary levels of energy and water consumption, and a wider scope for potential savings. Suggestions for significant reduction of sustainable upgrade costs are: - Prioritizing upgrade projects focusing on entire building structures as opposed to single housing units. - Opportunities to incorporate sustainable technologies in renovation projects already planned and funded for purposes such as reinforcement of residential structures, maintenance of public housing, improvement of building facades, etc.

Two main categories of economic mechanisms are presented to help households finance installation of efficient technologies: 1 ) Grants Programs for needy populations 2 ) Guaranteed loans and subsidized financial packages – with additional framework options such as electricity/water tariff rebates or imposed obligation on utility companies under terms of license to implement resource efficient projects in residential buildings

This study shows that incentive-oriented economic mechanisms employed to supplement insufficient savings generated by reduced operating expenses can improve viability of sustainable upgrade, for the benefit of average households.

A list of regulatory, statutory, management and administrative measures are recommended to expedite the successful implementation of resource and cost efficient upgrade initiatives. These offer a first step toward promotion of pilot programs to provide grants and subsidized loans to existing projects that incorporate sustainable upgrade specifications.

### ***The impact of a manmade oasis on human thermal comfort in a hyper arid environment: The case of Southern Israel***

**Oded Potchter**, Daphne Goldman, David Iluz, David Kadish, Gad Gilboa and Michael Sofer; Tel Aviv University, Israel, potchter@post.tau.ac.il

The hyper-arid environment is characterized by extreme seasonal and diurnal fluctuations in climatic conditions: Summer temperatures can exceed 40°C and winter temperatures can drop below 0°C. Diurnal temperature differences can exceed 20°C in both summer and winter. Consequently, inhabitants of this environment are exposed to extreme summer heat stress and severe winter cold stress. The potential use of vegetation for passive climate mitigation is increasingly recognized. Previous studies on the climatic effect of oases have demonstrated that the oasis can be cooler than its surrounding desert environment during the summer and warmer during the winter, and these effects are related to the type of vegetation cover.

The aims of the present study were to examine the influence of different types of vegetated landscapes, in and around a desert agricultural settlement on human thermal comfort in summer and winter seasons, as calculated using the Physiological Equivalent Temperature (PET) index.

Climatic variables were measured by fixed meteorological stations placed in different locations in and around the settlement, representing different types of vegetation cover and landscape: an east-west avenue with densely planted irrigated trees; a north-south avenue with sparsely planted irrigated trees; an open grassy area dotted with trees and surrounded by buildings; a grove of un-irrigated local desert trees at the southeast margin of the settlement; an intensely irrigated date plantation; natural desert environment.

Results demonstrate different diurnal and seasonal trends in the different research sites: In the summer, during daytime, despite small temperature differences between the varied vegetated stations, shaded areas of the oasis were significantly more comfortable compared to the desert. During summer nights, the cooling effect of the oasis did not necessarily increase comfort compared to the desert, due to the combined increase in humidity and wind blockage. In winter, although the desert environment was warmer than the oasis, during the daytime the oasis was more comfortable as a result of blockage of wind. During the winter nights, the oasis was much more comfortable due to the combined effect of warming, wind moderation and hindrance of radiation cooling. It appears that the influence of wind on human comfort is selective in different temperatures.

Results indicate that vegetation can be selectively used in the extremely arid environment as a tool for improving human thermal comfort, the extent of which depends on the type of vegetation and of vegetated landscape. Results suggest that tall trees with well developed canopies inhibit incoming short-wave radiation during the summer, thus preventing increase of the PET, and outgoing long-wave radiation in the winter thus preventing reduction of the PET. Another means for climatic amelioration is through the influence of trees on wind: during the summer- by blocking the warming effect of strong hot wind which would otherwise increase the PET, and during the winter by reducing the wind-chill effect of wind. Results also indicate that grass does not contribute to improving human comfort: it provides no shade, has limited influence on wind, increases humidity and long-wave radiation.

Findings of this study provide information useful in the planning process of mans' habitats in arid climates. In an era of global warming, findings may have implications with regards to the use of vegetation as a tool for mitigation of temperature increase.

### ***Environmentally responsive strategies for building design and electricity savings in hot hyper-arid regions***

**Alex Cicelsky**, Israel, alex@klotan.co.il

The deep hot hyper-arid valley between Israel and Jordan presents unique design and construction challenges for energy conservation and thermal comfort. Winters are relatively mild, summers extremely hot during the day, with night air temperature remaining above 25°C. Such conditions present real challenges in this sparsely populated yet rapidly developing region. Development depends on the ability to provide acceptable indoor environments at a low energy investment. Potential solutions were investigated through a parametric analysis including physical and operational elements aiming at establishing benchmarks for free running, low energy buildings under extreme conditions. First, building performance was simulated for a limited number of parameters. Additional operational and physical parameters were introduced and results compared. Data were analyzed to determine the best performing options for building assemblies.



Permutations investigated confirmed that conventional building systems did not allow for free running operation and that mechanical systems for heating and cooling were needed. This research concluded that it is imperative to extensively insulate building envelopes in order for them to be free running in winter. Extensive shading is needed in the transition seasons to allow for free running operation and avoid overheating. Completely shaded buildings, high efficiency window systems and levels of insulation above those currently employed when simulated with summer climate conditions had significantly lower energy consumption requirements than other building designs. The research showed that energy efficiency in this region depends on a combination of extensive insulation, full shade, high performance windows, air tightness and seasonal operation of window shutters utilized together.

Electricity consumption and climatic behavior of ten housing units with extra thick insulation in Kibbutz Lotan's eco-campus were monitored for a year. The housing units were specifically designed to be energy efficient. In controlled, unoccupied conditions they used 50% less energy for cooling than conventional buildings in the Southern Arava (Golding, J., 2010). The purpose of the monitoring program was to evaluate their energy consumption while occupied for an entire year.

The insulation material of the units was 50 centimeters of straw, a renewable, natural resource. The units were dome shaped, formed on a geodesic structural framework. The floor area of each dome was 20m<sup>2</sup>. The domes were occupied by one to three ecological volunteers. Electricity consumption of the auxiliary buildings and services in the eco-campus was also monitored.

Electricity production of nearby 0.68 kWp photovoltaic solar panel array was monitored concurrently in order to determine the size of photovoltaic system required to make the eco-campus energy neutral and/or energy independent. Electricity consumption of the entire eco-campus, domes and auxiliary buildings, was compared to that of six conventionally built concrete housing units. Each concrete unit had a similar floor area and was occupied by two kibbutz volunteers. The occupants used air conditioners for heating and cooling throughout the year as needed. The eco-volunteers utilized air conditioners only for cooling in the summer. The insulated units were heated by direct solar gain in the winter. Electric water heaters supplied hot water for the standard units all year. Eco-campus hot water was supplied by solar absorbers and supplemented by an auxiliary electric boiler for two months in the winter. The main findings were:

- The average electricity consumption per inhabitant in the eco-campus was 1.02 kWh/day versus 5.2 kWh/day in the concrete units.
- The yearly electricity consumption in the insulated eco-campus housing units was 29 kWh/m<sup>2</sup> compared to 167 kWh/m<sup>2</sup> in the concrete units.
- In summer months the average consumption of electricity in the insulated eco-campus housing units was 2.8 kWh/day compared to 5.2 kWh/day in the concrete units.
- In January, when external temperatures were as low as 8°C, temperatures in the passive solar heated insulated eco-campus units stayed above 18°C. The temperature range within the dome was only 3°C.
- Correlation between eco-campus' electricity consumption and production of the nearby PV system showed that a solar panel array of 3.5 kWp would suffice to make the eco-campus net energy neutral. A solar array of 6.8 kWp would be necessary to meet the peak demand of all ten insulated, air conditioned housing units and would ostensibly allow the entire eco-campus to be energy independent.

The significantly low electricity consumption of the eco-campus was the result of two factors. Firstly, the eco-campus dome housing units had energy efficient, climate specific designs. Secondly, the motivation of the eco-volunteers to properly operate their housing units in order to reduce electricity consumption was influential.

### ***Cooling the cities: mitigation and adaptation techniques to counterbalance urban overheating***

**Mat Santamouris**, University of Athens, Greece, msantam@phys.uoa.gr

The temperature of cities continues to increase because of the heat island phenomenon and the undeniable climatic change. The observed high ambient temperatures intensify the energy problem of cities, deteriorate comfort conditions, put in danger the vulnerable population and amplify the pollution problems. Higher urban temperatures increase the energy consumption for cooling and raise the peak electricity demand, intensify the pollution patterns in cities and increase the ozone concentration, deteriorate the outdoor thermal comfort conditions, increase the ecological footprint of the cities, intensify the health problems and increase the indoor heat stress on low income population.

To counterbalance the phenomenon, important mitigation technologies have been developed and proposed. Mitigation techniques aim to balance the thermal budget of cities by increasing thermal losses and decreasing the corresponding gains. Among the more important of the proposed techniques are those targeting to increase the albedo of the urban environment, to expand the green spaces in cities and to use the natural heat sinks in order to dissipate the excess heat. Recent real scale applications involving the use of the above mitigation techniques have resulted into very important climatic benefits and a serious reduction of the heat island strength.

The objective of the present lecture is to review, in a critical way, the available scientific information on the mitigation and adaptation potential of the major available technological developments. In parallel, to present the actual information on the impact of urban overheating on energy, health and quality of life. New data on the specific impact on the energy balance of buildings will be given. The impact of the urban overheating on low income population is also analysed. The lecture aims also to combine and analyze the existing theoretical and experimental data, compare and homogenize the results and if possible, to provide general conclusions and suggestions.

### ***Improving outdoor comfort and energy consumption of a city district in a desert area***

**Silvia Coccolo**, J. Kaempf, F. Vigliotti, J.-L. Scartezzini, Italy, silvia.coccolo@epfl.ch

The increase of the population, the growing urbanization and the climate change are the future challenges for a sustainable urban development. This research proposes a methodology to illustrate the relation between the outdoor human comfort in the built environment and the energy consumption of a group of buildings.

The outdoor conditions and energy consumption of buildings are strictly related: in the same climate the urban geometry directly influences the city microclimate, improving or reducing the well-being of pedestrians. The envisaged methodology makes use of Urban Energy Modelling, by the way of a software named CitySim, to define the outdoor conditions, considering the energy exchange between the pedestrian and his urban environment. The pedestrian was designed using a parallelepiped; the energy exchange between the pedestrian and his outdoor environment were determined using computer simulation. The variables considered are the clothing resistance and the metabolic rate of the pedestrian. The thermal comfort conditions were estimated according to the Index of Thermal Stress (ITS) suggested by (Erell, Pearlmutter, & Williamson, 2011). The approach was validated first with results obtained by a similar model developed at Ben Gurion University of Negev, showing a maximal relative difference of 10% between both results.

The second part of the analysis considers the validation of the model realized using CitySim and the software ENVI-met (Bruse, 2004). This part of the work considers the analysis of the mean radiant temperature in an urban canyon, as input variables, in order to estimate the outdoor human comfort.

The pedestrian comfort was applied in a real case study of a school campus in Dubai: the project realized by the architect was analyzed and optimized by reducing the hours of discomfort for the latter, according to the metabolic rate and clothing. The optimal configuration, to reduce the hours of discomfort in the campus, was compared with the first design realized by the architect, showing how the urban form impacts the urban microclimate and energy consumption of buildings.

This study presents a new service offered by the CitySim software, which can help the designer to analyze and optimize the outdoor human comfort and the energy consumption of buildings in a city district. The study of these two elements as well as their relationship can also support the architect in his quest for the sustainability of the city, improving the outdoor microclimate, and reducing the cooling loads of buildings.

### ***A design tool for water-efficient green open-spaces in the Israeli arid climate***

**Daphna Drori**, Technion Israel Institute of Technology, Israel, daphna.drori@gmail.com

The water issue is a crucial matter in Israel and in other arid places around the world. In Israel not only does water scarcity prevail, but there is also a constant increase in water demand due to the population growth and quality of life rise. Moreover, energy investment is needed at every stage of the water supply chain; from deriving water to conveyance. Thus, greater water use also results augmentation of energy-consumption. In order to reduce water consumption, the common action of governments is raising water tariffs. This causes phenomena like the negligence of open spaces, and the drying out of gardens. Unintentionally, the implementation of water-efficiency policy results the deterioration of the green environment, instead of coping with a proper design guidelines of green open spaces. In order to design water efficient gardens, a Knowledge-Based Computer-Aided Design Tool (KBCAD tool) was developed. Special emphasis was put on the climatic adjustment of the garden for the comfort of the plants and the people in a similar way to the bio-climatic design of buildings. This includes: considering the solar radiation, wind, and orientation in order to maximize the microclimate conditions of the garden, and to minimize the evapotranspiration from the plants and soil. Evaporation increases in hot dry climate, and therefore water sensitive design becomes significantly important in this case.

The water-efficient garden design tool (WEG tool) is based on the "Pattern Language", conceived by Alexander and implemented by E. Mazria in "The Passive Solar Design Handbook". The tool directs the planner to adjust the design to the autochthonous conditions of the site and recommends a variety of options for effective and efficient design. It includes a quantitative part that is integrated with the qualitative part, and enables an evaluation during and after the design process.

The WEG tool was implemented in R&D process for the water chapter of the Israeli "Sustainable Building" standard SI- 5281. It was used to define a reference garden, and a set of the improved gardens, for the performance-based and the prescriptive-based methods. Climatic analysis was performed and five climatic zones for plants were determined, considering the distribution of the lateral precipitation strips, as well as the longitude evapotranspiration strips. Each climatic zone has a specific reference and improved gardens; thus, enable the design of water efficient gardens accordingly. This paper will discuss the standard requirements, but also the differences between arid and semi-arid gardens.

### ***Biophilia and drylands architecture: visions for future living***

**Benz Kotzen**, University of Greenwich, U.K.; b/kotzen@gre.ac.uk

Mankind has found numerous ways of being able to adapt to and live in arid and drylands. The Bedouin are probably the best known for adapting to their environment, but they had the advantage of being able to 'up sticks' and move when life became unbearable (when grazing was depleted, wells were dry etc.) Permanent settlement, however, on the other hand relies on stable conditions in the supply of basic needs; water, sanitation, food and jobs. However, these supplies are in the long term mostly 'unsustainable'. In other words these types of settlements are subsidised in the supply and cost of water, in energy, materials, food and labour. We are at a point in man's evolution where sustainable living is not a pipe dream, but could become a reality. This realisation has at its core the premise that man needs to live with nature and not at the expense of nature.

The biophilic house and biophilic settlement relies on integrating nature as an integral part of life and the fabric of the house and community. This paper investigates the incorporation of nature as well as food production through the use of living walls, green roofs and aquaponics. Designers and planners have the opportunity to develop the ideas of Le Corbusier of the house as a real machine for living. This concept can now be realised where houses and communities provide their own energy, (including algaepionics) insulate themselves from harsh conditions and grow their own food. Water can be reused and nature exploited as part of holistic living. Insulation and biodiversity can be attained via poikilohydric and other extreme plant species and food grown within living walls and aquaponic systems which additionally provide thermal insulation and sustenance for the stomach and the soul.

***Sustainable development promoting local tradition: the work of Terrachidia in the M'Hamid Oasis (Morocco)***

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This paper would present the work Terrachidia Association is developing in Southern Morocco, in M'Hamid, the last oasis in the valley of the Drâa River, where the roads end and the caravan routes through the Sahara Desert once started.

Terrachidia is an independent association of interdisciplinary professionals whose aim is to contribute to the preservation of the traditional sustainability of the built environment, mainly through national and international teaching activities. This sustainability is understood as lying on keeping local building traditions alive and promoting worldwide the main values they embody. This work is developed through practical workshops specially focused on earth building techniques. Through these workshops we study, restore and promote the architectural heritage of this oasis, a fragile environment where building traditions are still alive, but more endangered than ever.

Palm groves are being little by little abandoned, allowing the desert dunes to progressively swallow this manmade landscape, while foreign architecture and urbanism practices are menacing its traditional balance. In this particular context, and due to its extreme climatic and social conditions, the main lessons which can be learnt from tradition are shown in a particularly clear way, making this place a wonderful school for our teaching purposes.

In these workshops participants learn the traditional building techniques of the oasis directly from local masters, who are hired and encouraged, along with young apprentices, to keep their crafts alive, contributing at the same time to the sustainable development of the region.

But sustainable development in a region whose current economy is mainly based on its touristic resources, thanks to the appeal of the Sahara Desert, also requires to enrich the way this tourism is understood, trying to improve its connections to local society and its cultural heritage. In these southern oases, by now, tourism is mostly focused on rallies through the desert and expeditions to Er Chigaga dunes. Meanwhile, the hospitable culture and the rich architectural heritage of these oases remain completely unknown and little by little disappear without any awareness of their possibilities to develop the area.

Once we identified this problem, working to solve it also became an important factor of our activities there. Wide and scientific studies of the local heritage and restoration works are being developed as a way to discover, underline and promote its multiple values. This promotion would be, in fact, one of the secondary aims of this paper.

***Hempcrete construction in Europe: the green alternative***

**Jacob Florentin**, Ben-Gurion University of the Negev, Israel

A significant portion of humanity's carbon emissions come from the construction industry and the usage of the buildings through their life span, and this is tightly related to the building materials used. Conventional, concrete-based building materials have high embodied energy, and without sufficient insulation they can lead to high energy demands for building climatization (heating and cooling). Here, a life-cycle energy and carbon analysis is proposed to evaluate the potential benefits of using an alternative, bio-composite building material made from hemp shives mixed with lime binder. While the employment of this family of materials has until now been marginal in the construction industry, industrial hemp has been used historically for countless products which exploit its unique physical properties including strength and light weight, and interest in its potential as an eco-friendly building material has grown in recent years.

## Desert Agriculture (Drip Irrigation)

### *Drip irrigation to save water or economize labor? A choice experiment in remote Zambia*

**Adam Abramson**, UC San Diego, USA

Drip Irrigation (DI) has been promoted across the developing world largely due to its high agricultural water use efficiency. In remote, low-resource settings, where household gardening is most often done by hand-watering, an additional attribute of DI—its ability to reduce the labor of irrigating—must also be considered. We conducted a hypothetical (stated preference) choice experiment among a rural community of Zambia to explore household preferences for irrigation method. In the survey, households (N = 150) were offered the inputs to conduct gardening either at their home or at a communal plot, and individualized profit margins and labor costs were estimated. Household preferences for irrigation method (drip irrigation vs. hand-watering) and location were elicited, and placed within their weekly time budget. Despite the technology's lack of use among these communities, most (69.3%) households opted to use DI at a community plot. When modeled, we found the distance to the nearest feasible household gardening site, the amount of water available at that site, and the financial set-up to be important factors in that decision. We present supplemental survey data to argue that saving water is of secondary importance to raising labor efficiency among households choosing to use DI.

### *Drip irrigation as a strategy for water scarcity at the small scale farming community levels in the arid zones of Sri Lanka: an empirical study*

**Ranjith Bandara**, University of Colombo, Sri Lanka

This study examines how small scale farming communities dealing with water scarcity adapt to climate change in regard to water management practices in Moneragala and Hambantota Districts whom benefited from a drip irrigation system which was introduced by the Ministry of Agriculture in Sri Lanka. This study was conducted by assessing a sample of 1,000 households chosen from the above two districts. Various qualitative and quantitative data collection methods were employed including questionnaires and field surveys and the data was collated utilizing 'before and after analyses' of the treatment group using selected indicators relative to a comparable sample of individuals outside the treatment. The socioeconomic impact on the beneficiaries of this intervention was assessed using paired "t" test to determine changing patterns and independent "t" tests to test differences in average annual income generated before and after using the drip irrigation system. The impact of the drip irrigation system on the housing condition and household facilities was assessed through field surveys which showed an impressive, quantifiable improvement both to the state of the structures as well as the facilities available therein. Furthermore, the source of household income and income generating activity, change in household expenditure and user perception on drip irrigation system were also assessed in the field survey in order draw a better and clear picture of the change in livelihood of the farming families of those who used the drip irrigation system. The annual average income of the households in the survey shows a clear increase in both districts which has led to a corresponding increase in expenditure and a higher standard of living with a more commercial outlook. However, it should be noted that some deficiencies, primarily in technology delivery and confidence building in rural communities are evident in the current phase of the drip irrigation system.

Thus, it is concluded that there is an urgent need to enhance knowledge amongst all parties and to bridge the gap for the efficient application of the new techniques. It is believed that the lack of farmers' confidence in the modern techniques is due to the fear of their sophistication, the lack of knowledge on them, and their high cost. Moreover to maximize the gains of this system when selecting farmers it is recommended that they be chosen in vulnerable locations to climate change, where crops that are selected adapt well to the climate variability of the location whilst arming the farmer with the necessary knowledge and guidance required to maintain the system. Consequently, the next phase in this project should be able to address the above mentioned drawbacks taking into consideration the results of this study. Furthermore, these issues should be looked at from a differentiated approach where the implementation approach is recommended to be utilized to bridge the few shortcomings of the present initiative and broader measures devised to increase accessibility of the drip irrigation technology to small holdings farmers.

### *Use of polymer membranes in drip irrigated systems*

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Irrigated agriculture currently produces 40% of the world's food using 20% of the total cultivated land but uses 70% of all freshwater withdrawals to do so. Meeting the food needs of a growing population will require irrigation to play an even more important role in the future than it has in the past, but with less water. This will require ongoing improvements in irrigation water and nutrient use efficiency. One way to address this is to increase the percentage of applied irrigation water taken up by the plant relative to that 'lost' from the root zone through soil evaporation and/or deep drainage. In this paper I describe use of the HYDRUS model to (i) analyse fertigation in drip irrigated systems to minimise fertilizer losses through leaching to groundwater and (ii) use of polymer membranes to improve water use efficiency. I describe surface energy balance and other enhancements incorporated into the HYDRUS model that enables assessment of the effectiveness of polymer membrane barriers to water flow in reducing soil evaporation. I discuss in particular the effects of albedo and partial surface coverage of polymer membranes on soil evaporation. The analysis shows that many small gaps result in greater evaporation loss than a few big gaps with the same total surface area. I conclude by highlighting areas in need of further research.

### *Drip irrigation via compost trenches*

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Drip irrigation is based on watering only a portion of the soil volume of land used for growing crops. Irrigation of orchards in arid conditions having soil lacking organic matter and with high salinity water presents the farmer with a challenge in managing the irrigation practice. He must ensure both the availability of water and the necessary nutrients on the one hand, while on the other hand improve the soil characteristics and protect economic performance over time. The Arad Valley has arid climate conditions (multi-annual averages of evaporation and precipitation - 2,600 mm and 120-150 mm, respectively), Loess soil with a low infiltration rate (IR <5mm/hr), and irrigation water based on Arad's effluent (EC > 1.8 dS/m, SAR > 6). Under these conditions the almond orchards have had continually declining yields, almost reaching total atrophy.

In the first decade of the 21st Century a unique project was carried out in the Arad Valley almond orchards in which a series of activities and means for improving the conditions for irrigation were developed and implemented. Within this project a method was developed for determining the proper location of the drip irrigation lateral in compost trench. In addition, basic balances of nutrients and salts were measured and computed, the hydraulic characteristics of the irrigation system were characterized (discharge, irrigation rate, ...), and the aspects of maintaining the system were examined under these factors.

Under this system the drip irrigation laterals were located at the bottom of a shallow ditch (with a triangular shape and depth of 15-20 cm.) High quality compost with a high composition of organic matter was placed above the lateral at a ratio of 50-100 m<sup>3</sup>/ha. The trench was covered with a thin layer of local soil. The implementation activities are mechanized. In plots larger than 5 ha having no large stones, the implementation can be accomplished in less than 5 days work per hectare.

In a number of observations made to compare the conditions and the accomplishments of the system that was developed with the usual practice, very good results were observed. These results pointed to a cessation of the degeneration process and to a significant improvement in the vitality of the trees, resulting in an increased yield of higher quality crops. The observations examined various types of drippers, different implementation methods, and the need and the frequency for revitalizing the compost trenches.

### *Solar-powered drip irrigation impacts on food security, economic development, and climate resilience*

**Jennifer Burney**, UC San Diego, USA

This talk presents a suite of results from 6 years of monitoring a community-scale solar-powered drip irrigation project in northern Benin, West Africa. As this project progressed from design to pilot to scale-up phases, we have evaluated its economic, environmental, and social sustainability, as well as its impact on household incomes and assets, food security and nutrition, and investments in human and social capital. We show positive impacts across this broad range of indicators, and also discuss the institutional constraints that must be addressed for more wide-spread uptake.

### ***The implications of fertigating olives with reclaimed wastewater***

**Arnon Dag**, Agricultural Research Organization, Israel

Olive orchards have been cultivated in the Mediterranean basin for thousands of years. However, such orchards produce low oil yields and typically are not profitable. Modernization in olive cultivation, mainly including introduction of high-yielding varieties, higher density planting, and irrigation and fertigation, has dramatically increased orchard productivity. Regions where olive cultivation is concentrated generally possess limited fresh water resources and alternatively utilize low quality water for irrigation. In the current study we tested the effect of drip irrigated reclaimed wastewater [RWW] on soil, olive trees and yield. The study lasting 8 years was conducted within a 20 ha. commercial high density olive orchard. Three treatments were tested: fresh water with standard fertigation (fertilization via drip irrigation) [FW], RWW with standard fertigation, and RWW with reduced fertigation (in accordance to the K and N available in the RWW). After the first four years the treatment with RWW and standard fertigation was shifted to RWW with reduced fertigation and the treatment of RWW with reduced fertigation was shifted to RWW without fertigation. The RWW was secondary-treated domestic wastewater from the city of Jerusalem and fresh water originated from the local coastal aquifer.

Trees received around half of their nutritional demand for N and K via the RWW. Water source and fertigation regime did not affect tree growth, nutritional status or productivity. Olive oil quality was not affected by use of RWW or fertigation regime. Soil salinity increased during the irrigation season in the RWW plots compared to the FW plots. However, during winter, the soil was leached by rains to base levels and no long term permanent increase in salinity was measured. SAR values also increased during the irrigation seasons and decreased following winter rains, but did not return to their initial values. Subsequently, a constant increase in SAR values was observed throughout the experimental years. SAR values of  $>8$ , measured at the end of the experiment, suggest possible soil degradation in the plots irrigated with RWW. Negative long-term effect to soil was further implied with the results from a biological assay. Biomass production in corn plants grown in soil collected from the RWW plots was significantly lower than that of plants grown in soil from the FW plots. We speculate that drip irrigation in orchards, which exposes a relatively limited volume of soil to very large volumes of water, might enhance soil degradation process while using low quality water containing high concentrations of solutes.

### ***Technological- Innovation for Poverty Alleviation (TIPA)***

**Tammy Erann-Soussan**, Mashav, Israel

Most of the Sahel is cultivated by small scale family farmers practicing traditional, subsistence farming, cultivating traditional staple crops year after year, during the rainy season alone, and often obtaining lower and lower yields annually, due to soil depletion and climate change. These small scale farmers of the Sahel generally lack the ability to contend, on their own, with the challenges of climate change, or with the degradation of their soil. Intensification of agriculture through the production of irrigated high-value crops is one way to overcome these natural limitations and the resulting food insecurity suffered by many in the region. The relative advantage for growing labor-intensive vegetables lies in small-scale family units where the smallholder can utilize family labor to achieve better results and significantly increase the family's income.

TIPA is an agricultural production and community development model based on drip irrigation technology, improved varieties/seeds for a mixture of vegetable and fruit tree crops, and a management package that assures the optimization of small scale farming and its transformation from subsistence farming to a commercially oriented production.

The model is based on the concept of the African Market Garden (AMG), a small-scale horticultural production package developed at Ben Gurion University of the Negev in cooperation with world-renowned Israeli irrigation companies. The TIPA model was later enhanced by MASHAV in cooperation with the International Crops Research Institute for the Semi Arid Tropics (ICRISAT) in Niger. It was first implemented in Senegal in 2006, and is currently being up-scaled to a national level through the trilateral cooperation program between Senegal, Italy and Israel, through the PAPSEN-TIPA project in the regions of Thies, Diourbel and Fatick.

While TIPA is essentially an agricultural production model, its scope extends beyond agriculture, with a significant socio-economic impact on the rural communities where it is adopted. Its benefits include labor saving, water saving, higher better quality yields, the ability to produce crops year round and a greater likelihood of maintaining the productive capacity of the soil. The decreased labor required by the drip irrigation for watering and weeding offers a direct benefit to women and girls in the community, and the majority representation of women in the implementation of the PAPSEN-TIPA project contributes to overall gender equality. The community management of larger issues such as water delivery, credit for the purchase of inputs, and plant protection practices increase the model's sustainability.

### ***Why are farmers adopting drip irrigation (or not) in India? Lessons from a study of 450,000 drip purchasers in Gujarat***

**Ram Fishman**, George Washington University, USA

Despite the great promise of drip irrigation to increase yields while reducing water and fertilizer use, rates of adoption by smallholder farmers in developing countries have tended to remain disappointingly low. Against this background, the rapid diffusion of drip irrigation in the Indian state of Gujarat in recent years stands out as a remarkable success story, with about 450,000 installations occurring since 2005. We use detailed, large data sets on each of these installations to conduct a thorough analysis of the drivers and consequences of this dramatic transformation and the determinants of adoption on a scale and level of precision that were impossible until now. We investigate the degree to which water scarcity and other geographical factors impact adoption, the process of diffusion from farmer to farmer and from village to village, the impacts on water and energy use, and the degree to which government subsidies reach the smallest land-holders. The results are relevant to the design of policies to promote drip in other parts of the world.

### ***DIDAS: A user-friendly software package for assisting drip irrigation design and scheduling***

**Shmulik Friedman**, Gregory Communar, Alon Gamliel, Department of Environmental Physics and Irrigation, Institute of Soil, Water and Environmental Sciences, Agricultural Research Organization, the Volcani Center, Bet Dagan 50250, Israel, vwsfried@agri.gov.il

The DIDAS software package was developed for the purpose of assisting irrigators in the design of drip irrigation systems and in irrigation scheduling. The program performs computations based on analytical solutions of the relevant linearized water flow and uptake problems. Water flow is described by superposition of solutions for positive sources (on-surface or subsurface emitters) and negative sinks (plant root systems). Steady water flow is assumed in the design module and unsteady flow is used in the irrigation scheduling module. The design tool is based on a new, relative water uptake rate (RWUR, ratio between water uptake rate and irrigation rate) criterion suggested for deciding upon the distances between emitters along drip lines and between drip lines. The maximum possible RWUR is evaluated assuming no plant-atmosphere resistance to water uptake. Namely, the plant roots apply maximum possible suction and the water uptake is determined just by the capability of the soil to conduct water from the emitters to the rooting zones. The computations of the RWUR requires only a minimum number of three parameters describing the soil texture, the size of the root zone and the potential evaporation, in the few cases when it is important to account for also evaporation from the soil surface. The irrigation scheduling optimizing tool is based on a relative water uptake volume (RWUV, ratio between daily water uptake volume and daily irrigation volume) criterion. The computations of the diurnal patterns of the water uptake rates and the daily RWUV for a given irrigation scenario require additional information on the diurnal pattern of the plant resistance to water uptake and on the hydraulic conductivity of the soil. DIDAS includes also a module of quasi-steady flow for evaluating the diurnal water uptake patterns that accounts for



the diurnal plant resistance and evaporation patterns and serves for fine-tuning of the design and preliminary evaluation of scheduling scenarios. DIDAS is programmed in DELPHI and runs on any Windows operating system-PC, with no further software requirements. The construction of the drip irrigation scenario is performed via few GUI windows, which contain also a library of the required input parameters, and several best-fitting procedures. The computed RWURs and RWUVs are displayed graphically and the tabulated output results can be exported to e.g. Windows Excel for further processing. A second version of the DIDAS freeware package can be downloaded from <http://app.agri.gov.il/didas>.

### ***Augmentation and enhance water use efficiency through farm pond and micro irrigation rainfed area of Kashmir valley***

**Rohitashw Kumar**, SKUAST-Kashmir, India

The study revealed the augmentation of water resources using low cost water harvesting structures, different water conservation techniques and improving water use efficiency of field crops in different districts of Kashmir valley. Numbers of water harvesting structures have been constructed for storage of water in hilly terrains at different slope and topography of the area. Water harvesting structures have been constructed using different lining material, source of water, type of harvesting (ex- situ, In-situ) i.e. stone masonry, brick lining, reinforced cement concrete lining, silpaulin lining and LDPE lining. The water harvesting tanks constructed for storage of snow melt and rain water of the capacities ranging from 25 m<sup>3</sup> to 200 m<sup>3</sup> and in the area about 70% farming is solely dependent on rainfall and snowfall for meeting the irrigation requirements of the crops. The harvested water efficiently used for irrigation during moisture stress periods thus resulting in making available irrigation to crops during water stress periods. Stored water efficiently used through micro irrigation system in different crops and increase water use efficiency from 40-60%. The water use efficiency evaluated for horticultural crops, row crops and floricultural crops under drip irrigation system along with fertigation and it was found to have a profound effect on the yield of the crops. It has been observed that, water saving from 30-60% and yield increase from 20% to 80% in different crops.

### ***Agronomic and ecological evaluation on growing water-saving and drought-tolerant rice through drip irrigation***

**Zaochang Liu**, Shanghai Agrobiological Gene Center, Shanghai Academy of Agricultural Sciences, Shanghai, China

Global agriculture in this century faces two major challenges. Total food production needs to increase to feed a still growing world population, and this increase needs to be accomplished under increasing scarcity of irrigation water resources. However, fresh water resources are increasingly getting scarce because of increased competition among a multitude of users from all economic activities. A field demonstration trial and a greenhouse pot experiment comparing the growth status, yield ability and water use efficiency of drought-tolerant rice varieties and normal paddy rice variety under drip irrigation and paddy irrigation were carried out for three years. Under drip irrigation, both inbred and hybrid water saving and drought resistant rice (WDR) varieties showed much better yield capacity than paddy rice varieties tested. WDR varieties under drip irrigation reached more than 95% of the yield level that achieved in paddy field, while the paddy varieties under the same drip condition reached only about 75%. The methane gas emission was obviously decreased under drip irrigation condition, while the emission of other greenhouse gas like nitrous oxide or carbon dioxide was not observed significant change between drip and paddy irrigation. It could be concluded that it is practicable to grow water saving and drought tolerant rice through drip irrigation. Drip irrigation maintained a competitive grain yield and water productivity, and greatly reduced pollution risk to the environment. Considering the conservative amount of fertilizer application, less than the amount of fertilization in normal paddy field, the yield potential of rice could be improved to a higher level if increasing the amount of fertilizer as top application or through fertigation in drip irrigation system. Weed control is also an important aspect in growing drip rice. In the end, effective weed control using chemical herbicides was proposed after 2 years of field demonstration of dip rice. For effective and large scale demonstration, mechanized drip rice and related techniques as well as practice were included.

***Irrigating more land with less water using water saving techniques: A review of challenges and technological options for Nguruman and Lari Wendani Schemes, Kenya***

**Edward Muya**, Kenya Agricultural Research Institute, National Agricultural Laboratories, Kenya Soil Survey, P.O. Box 00800-14733, Nairobi, edwardmuya@yahoo.com

In Nguruman Irrigation Scheme, the available water supply has the capacity to meet irrigation water requirement of 5,299,479 m<sup>3</sup> to irrigate the 800 ha per year. However, there is bound to be water shortage in the near future if all the irrigable land of 1,200 ha is brought under production. With increasing population and escalating number of farmers engaging in irrigated agriculture, more area is expected to be brought under irrigation to meet the increasing food demands. In Lari Wendani, the targeted area is 100 ha, while the available water supply from the source is not only very low, but also on a downward trend due to adverse impacts of human activities in watershed areas. In both schemes, the demands for water will not be fully met by the available water supply in the near future unless appropriate water saving technologies are identified, validated and disseminated. For this reason, analysis of challenges and technological options for improved water use efficiency was carried out in terms of the merits of different techniques of irrigation water application, quantities of water saved and additional area that can be irrigated by each of the technologies reviewed in relation to the farmers' practices. The technological options reviewed were: drip irrigation plus digital instruments; drip irrigation plus analog instruments; sprinkler irrigation plus digital instruments; sprinkler irrigation plus analog instruments and farmers' practices. It was found that drip plus digital instruments, drip plus analog instruments, sprinkler plus digital instruments and sprinkler plus analog instruments saved 453,601, 433,132, and 386,977m<sup>3</sup> respectively. No water was saved by the farmers' practices. The total additional area to be irrigated following the significant water savings from the four technologies was found to be 508 ha.

***The evolution of drip irrigation: a personal account***

**Dov Pasternak**, Ben-Gurion University, Israel

The presentation describes the evolution of the drip irrigation system in Israel starting in 1964 when it was introduced to four settlements in the Arava Valley ending with remotely controlled systems for water and fertilizer delivery. Yaakov Mottes was the first to publish an article about drip irrigation in 1962. At about the same time Mr. Simcha Blass started to study the use of drip ending up with the spiral drip emitter that allowed even distribution of water along the drip lateral.

Yehuda Zohar from the Ministry of Agriculture was responsible for the first successful introduction of drip irrigation to Israel. He also introduced three principles that are responsible for much of the success of this system:

These are:

- Daily irrigation
- Irrigation based on evapotranspiration
- Fertilizer application in the water with each irrigation

The original objective of drip irrigation was water saving. However it was soon found out that drip irrigation is particularly suitable for irrigation of poor desert soils, for use of saline water for irrigation of both sandy and heavy soils with low water permeability and for irrigation of soil-less systems.

Drip irrigation evolved over the years into a sophisticated system incorporating:

- Use of soluble fertilizers including both macro and micro elements,
- Use of irrigation controllers, giving a predetermined amount of water to the field
- Irrigation computers
- The labyrinth emitter that markedly reduced drip clogging
- Insertion of emitters into to drip laterals allowing mechanical handling of laterals
- Development of pressure regulated emitters allowing the use of drip in undulating terrain and sloppy areas
- Buried drip irrigation

- Low pressure drip systems for energy saving
- Self-cleaning water filters allowing use of turbid waters for drip irrigation
- Use of internet for remote control of drip irrigation

The presentation will describe in some detail all these above developments with emphasis on the account of the first introduction of drip irrigation to the Arava Valley, the importance of drip for saline water irrigation, the use of low and high pressure drip irrigation for small poor producers and the role of "Netafim" of national and international propagation of the system.

### *Advances in fertigation*

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Irrigation and fertilization are arguably the most important management factors in arid and semi-arid climates, through which growers can manipulate crop yield and quality. The main technical advancement regarding nutrient management in the 20th century was the application of liquid fertilizers via drip irrigation systems (fertigation). There are many advantages of fertigation including: the application of nutrients and water is accurate and uniform under all circumstances; application is restricted to the wetted area, where root activity is concentrated; the amounts and concentrations of specific nutrients can be adjusted to crop requirements according to the stage of development and climatic conditions; reduced time fluctuation in nutrient concentrations in soil over the course of the growing season; it enables irrigation with higher saline water than other irrigation methods; crop foliage is kept dry, thus retarding the development of plant pathogens and avoiding leaf burn; energy use is reduced by the avoidance of broadcast operations and because of the lower water pressure required for trickle irrigation relative to sprinkler systems; soil compaction and mechanical damage to crops are reduced because there is less tractor traffic; convenient use of compound, ready mixed and balanced liquid fertilizers, with minute concentrations of minor elements which are otherwise very difficult to apply accurately to the field; and it is the safest method for irrigation with sewage effluent. A continuous supply of readily soluble nutrients via fertigation directly to the root zone maximizes economical yield and minimizes over-fertilization and pollution of groundwater by salt and nutrient leakage.

## **Desert Ecology**

### *Resilience and recovery of semi-arid annual plant communities to drought*

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Dynamics of semi-arid annual plant communities result from the demographic responses of the species to inter-annual variation in rainfall, and their contribution to the community. In turn, the species' responses depend on their recruitment from seeds produced in previous years, and are controlled by seed traits for dormancy-breaking and germination. The traits vary among dryland annuals from germination of a fraction of the dormant seeds in a persistent seed bank when soil moisture is high (known as "delayed" and "predictive" germination), to rapid germination upon wetting from a transient seed bank, with no remaining dormant seeds.

I hypothesized that at the population level, germination traits in species with and without secondary dormancy are represented by site- and seed-limited recruitment, respectively. I also hypothesized that the latter should display strong dependence on previous year's rainfall due to fecundity and seed production, while the former depend on current year's rainfall alone. At the community level, I hypothesized that the non-dormancy species contribute most to

resilience during a drought year, while the ones with prolonged seed dormancy are responsible for recovery afterwards.

I tested the hypotheses using two datasets from the Park Shaded LTER site with yearly censuses of annual plant abundance in species-rich communities of natural and artificial patches over 12 and 8 years, including alternating years with high, medium and low rainfall and a sequence of two dry years.

Results confirm the hypotheses. The dominant grasses, *Stipa capensis* and *Bromus fasciculatus*, that lack secondary dormancy, showed a significant positive previous-rainfall effect. Current year's rainfall positively affected density of all species, as well as patch-type differences, temporal autocorrelation, and in some species negative effects of *S. capensis* density. Notably, some common forbs responded negatively to previous rainfall, due to surface exposure after dry years.

Resilience of the communities is reflected in rapid recovery after drought by forbs with persistent seed banks, and maintenance of plant abundance during single dry year by the non-dormancy grasses, especially on crusted inter-shrub surface. However, this also implies a vulnerability during sequences of dry years, which may become more frequent as predicted by climate change models.

### ***Bee and plant species diversity and interactions along climatic and land use gradients: the case of Wadi Nar and Wadi Daraje***

**Ariela Gotlieb**, Ismail Arar, Dead Sea and Arava Science Center, Ein Gedi Branch, Skin Lab, Kibbutz Ein Gedi, 86980, ariellag@adssc.org

Wadi Nar/Kidron, which begins in Jerusalem, passes through the Judean Desert and ends in the Dead Sea, has suffered many years of pollution and neglect. A comprehensive master plan was created for the basin a few years ago, and a waste water treatment plant is supposed to collect the 35,000m<sup>3</sup> flowing through it today. In preparation towards its rehabilitation, we started a plant and pollinator monitoring program, recording the current state of affairs in the wadi.

Pollinators are vital to the sexual reproduction of most plant species in both agricultural and natural systems, and maintaining a diverse community of pollinators ensures good pollination services for agricultural crops and natural vegetation alike. Bees are one of the main groups of pollinators, and their diversity and sensitivity to changes in the ecosystem makes them good indicators of ecosystem state. Plants are greatly affected by changes in environmental conditions and enable to easily track changes in the ecosystem as well. Monitoring the visitation network of plants and pollinators provides a clear view of ecosystem functioning.

During the spring of 2014 we sampled plots along Wadi Nar and its unpolluted neighboring wadi, the Daraje from Jerusalem, through the desert towards the Dead Sea, encountering climatic gradients, pollution gradients and grazing. During the talk we will discuss our initial findings there.

### ***Investigating spatial and temporal patterns of plant health of *Welwitschia mirabilis* in the central Namib Desert***

**Titus Shuuya**<sup>1</sup>, Barbara Curtis<sup>b</sup>, Theo Wassenaara, Gert Krüger<sup>c</sup>, Jacques Berner<sup>c</sup>, Kathy Jacobson<sup>d</sup>, Angie Kanandjemboe, Michele Kilbourn Louwe

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*Welwitschia mirabilis* is a long-lived gymnosperm endemic to the Namib Desert. It occurs from the Kuiseb River in Namibia to the Nicolau River north of Namibe in Angola, in a region where the rainfall varies from <50mm to about 200mm p.a. It is protected by law in Namibia and is also listed as a CITES Appendix II plant. *Welwitschia* is a unique plant, both in appearance and biology. It has been one of the main tourist attractions of the central Namib and a subject of several scientific studies. In the central Namib, there is a reference population of about 52,000 individuals occurring south of but adjacent to the developing Husab mine, slated to become the second-largest uranium mine in

the world. The cumulative impacts from the developing mine (potential impacts include interference with water supply and deposition of dust) are likely to be additional to the factors that affect plant health, yet it is not known how *Welwitschia* will respond to these potentially deleterious conditions. These impacts and the changing baseline conditions might affect their physiological processes, thus their growth and reproduction. In this study we investigate plant health (leaf growth rate, reproductive parameters and photosynthetic efficiency) as a function of topography, geology, proximity to dust sources and dust loads and how these change over time. Our preliminary investigations show a clear effect of topography, with plants in drainage lines and plants closer to the bottom of the catchment being clearly healthier than others. Dust generated by exploration and test-mining activities, as well as by vehicles on a gravel road had a significant effect on one measure of photosynthetic efficiency. The study is continuing, focusing on the correlation between finer resolutions of physiological health and landscape parameters. We aim to provide possible management strategies for mines and other developments that may have adverse impacts in the extreme dry land conditions. Besides that, the findings may also aid restoration measures such as translocation and re-introduction of this unique plant.

## Desertification in Mongolia

### *Transformation of traditional organization in the transitional period of rural Mongolia*

**Batyav Batbuyah**, Institute of Geography, Mongolia; b\_batbuyan@yahoo.com

Since the 1990s Mongolia has experienced complex environmental, socio-economic, and political changes. In a country where the grassland environment comprises over 80 per cent of the territory, mobile pastoralists make up 50% of the population and depend on pastures, surface water, and wells for animal production. Due to climate changes there has been a decrease in pasture productivity, which has introduced many challenges for rural livelihoods and has put a strain on social institutions. Climate change has also affected land use patterns and pasture sustainability. There is an increasing pattern of migration to ecologically favorable areas. Over the last decade, herders in Mongolia have organized themselves in different organizational forms to manage pastures, protect biodiversity and to improve their livelihoods. Over 2000 “herder groups” and “pasture user groups,” were established. These organizations are more or less formalized and many of them were initiated and supported by donor projects. However, the observations and data we have suggest that within the current political administrative territorial structure and social-ecological conditions, informal organizations such as the rural *khot ail* are still a key institutions that retain the principles of common resource use and mobility, which are rooted in cultural tradition and based on ecological necessity. A recent study indicates how new climatic and social conditions transforms traditional organization into a mechanism with new features and illustrates how the transition period has impacted social relationships and is in the process of creating a new basis for the future of pastoralism in Mongolia.

### *Explaining spatial variations in climate hazard impacts in western Mongolia*

**Nick Middleton**, University of Oxford, UK; nicholas.middleton@ouce.ox.ac.uk

The harsh winter of 2009-10 induced a mass loss of livestock known as “dzud” in Mongolia. This paper examines marked local variability in vulnerability to the wintry conditions in a western Mongolian province (Khovd aimag). It identifies striking differences in livestock mortality that are explained with reference to site-specific circumstances. We ascertain a counter-intuitive pattern of milder winters with less snow in Upland districts when compared to Lowland districts, a contrast that was particularly acute in the winter of 2009-10. Implications for hazard management and governance are discussed, as are recent policy initiatives. Our findings provide empirical support for the argument that reducing socio-economic vulnerability to climate hazards – an aim of research and policy communities in both disaster risk reduction and climate change adaptation – requires an appreciation of local, site-specific conditions.

***Contrasting strategies in a similar environment: comparing Gobi pastoralists' livelihood trajectories in transformed Mongolia and China***

**Henri Rueff**, University of Oxford, UK; henri.rueff@ouce.ox.ac.uk

Herders in dryland extensive pastoral systems use resources dispersed in time and space in an opportunistic way due to erratic rainfalls. Pasture rotation with strategic mobility are the main management characteristics of these systems. Mongolian and Inner Mongolian pastoralists share similar environments in the Gobi desert but have contrasting forms of pasture management. In the former, mobility remains a key strategy year-round while winter fodder preparation is minimal. In the latter, the Chinese government has enforced a pasture control policy restricting mobility and the number of animals per herder with fenced pastures and a large scale winter fodder preparation infrastructure. Inner Mongolian herders receive a payment for ecosystem services compensating for their reduced productivity, in line with the environmental rhetoric used by the Chinese government to justify pasture control. It remains nevertheless unclear how these two systems compare in terms of livelihoods of herders and the sustainability of these systems. This study proposes an overview of a survey conducted among 360 pastoralists evenly distributed across the China-Mongolia border. The hypothesis tested is that despite pasture fragmentation, sedentarization, and a decline in livestock number (at least in the official statistics) reared on Chinese grasslands, the wealth band distribution of Inner Mongolian pastoralists remains somewhat comparable to that of Mongolians'. Transformations of the pastoralism environment in the Gobi generates new formal and informal strategies, livelihood trajectories, and opportunities but also new forms of uncertainties and vulnerabilities. Understanding these new norms shaping today's extensive pastoral systems in the Gobi is important in a region where the value of livestock products increases substantially with a growing demand, making the existence of these socio-ecological systems increasingly relevant.

***Dry land pasture degradation and climate change adaptation development for Gobi region in Mongolia***

**Tsolmon Renchin** and Suvdantsetseg Balt; National University of Mongolia, Remote Sensing and Space Science Laboratory, Ulaanbaatar, Mongolia

The impacts of climate change are critically affected to Gobi desertification, biodiversity loses, poverty of nomadic herders livelihood, loses of livestock number, decreases of water sources, degradation of pasture rangeland and mining activities in Gobi region. While climate change is requiring great challenges and adaptive solutions on the all spheres of human environment, development of policy strategies for the local to national level to strengthening resilience on its impacts and implications. The main focus of climate change adaptation is to support pastoral adaptation managements in their resilience strategies to close the gap between advanced scientific knowledge and the political regulations of practical ground. In order to establish the pastoral resilience is necessary to provide strong evidence based on appropriate policy, technological and scientific developed solutions for common practices of communities usage. This research project is developed early adaptation system based on scientific study, solution of all level's realized in Biger sum of Gobi-Altai province, Mongolia. With the future extension of system development in the country should consider the customers' application or request, identification of knowledge gaps, investment of policy makers, collaboration of industrial technological development and support of pastoral communities that is techniques' development or potential technical resources, and capacity building in each of stakeholders especially for the Gobi region in Mongolia.

## Deserts and Drylands in Ancient Literature and Archaeology

### *Monasticism in arid and semi-arid landscapes in late antiquity: Between holiness and economy*

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Monasticism is synonymous with arid landscapes since its birth. One of the most common titles used in most languages for monk is Hermit, a noun that derives from the Greek *eremos* = Desert. The first hagiography that was written by Athanasius of Alexandria in the mid-4th century, and that was dedicated to Saint Anthony, concentrates mainly on the struggles of the saint to exercise his anachoresis in the extreme conditions of the deserts of Egypt. In this hagiography, Athanasius set the future, both for hagiography as a genre and for the monk as a hermit. In Palestine, this synonymy is depicted in the lives and foundations of the monastic exemplars that settled in the deserts of Jerusalem and in Sinai. Cyril of Scythopolis dedicated seven hagiographies to the monks who – using a phrase adopted from Athanasius “Life of Saint Anthony” – “turned the desert into a city”, and other monastic writings stores valuable data on monastic life in other deserted landscapes like the Negev and Sinai. What is common to these writings is the depiction of the monks as a remote organ, detached from, and sometime even hostile to lay society. The monasteries in these arid landscapes lived in autarchic communities in a seemingly hostile surrounding that served as a perfect background for practicing ascetism. However, reading hagiographic literature, reinforced by advanced archaeological research, indicates a much broader scope of monastic settlement in arid and semi-arid areas. It appears that the construction of monasteries served as an efficient and convenient way to cultivate deserted lands in arid and semi-arid areas. This economic roll turned monasticism to serve as one of the most significant expressions of the economic boom of the 5th and the 6th centuries in the Levant. Though less glamorous in its holiness, it appears to be one of the most fascinating social and economic phenomena of late antique Levant.

### *Cities in the steppe drylands: The case of Qara Qorum, capital of the United Mongol Empire*

**Michal Biran**, The Hebrew University, Israel; biranm@huji.ac.il

Around 1235 Chinggis Khan's heir, Ogodei Qa'an, established a capital to the ever-growing Mongol empire. The capital, known as Qara Qorum (Black rocks) was founded in the nomads' sacred territory in the Orkhon valley in Central Mongolia and became a cosmopolitan and multi-cultural city, frequented by people from eastern and western Eurasia. It served as the Mongol capital up to 1260, when Qubilai Khan transferred the capital from Mongolia to China, thereby leading to the city's gradual marginalization.

Based on a wide variety of multi-lingual literary sources as well as archaeological records (including the results of the Mongolian-German-Israeli excavations in summer 2014) and climatic studies, the paper analyzes the economic, political, and ecological challenges of establishing an imperial capital in the steppe, how the Mongols solved them, and what were the reasons for the transfer of the capital and the city's decline.

### *Trails and people: Selecting a route in the desert*

**Eli Cohen-Sasson**, Department of Bible, Archaeology and Ancient Near East, Ben-Gurion University of the Negev; eli.timna@gmail.com

Selecting a walking path is a complicated task which includes many variables in a different importance level, such as: topography, geology, water resources, borders and many more. Weighing the various components in geographical information system (G.I.S) and building a predictive model of "ideal" walking trails can aid to reconstruct the consideration of the people who used it in ancient times. In my lecture I will discuss computer analysis of ancient trails and its contribution to the archaeological research using three case studies: one from the Judean Desert, the second from the Negev Highlands, and the third from the Southern Arabah.

***The people that came and went: Har Michia, resources and landscape, an archaeological approach***

**Davida Eisenberg-Degen**, Israel Antiquities Authority, Israel; degendavida@gmail.com

An archaeological survey conducted at Har Michia sheds light on the different uses of the Negev Highlands throughout the periods. The earliest remains of human activity at Har Michia are attributed to the Middle Paleolithic with the identification of six large flint scatters. In later periods Har Michia continued to attract human occupation. Based on finds at the site and comparisons to other excavated sites, people of the Early Bronze Age and later periods chose Har Michia for settlement, based on considerations other than the flint bulbouses. The lecture with an attempt to answer which resources drew people to the site over the past 250 ka years.

***What a relief – stone architectural decorations in the Byzantine Negev***

**Karni Golan**, Ben-Gurion University of the Negev, Israel; golank@post.bgu.ac.il

Stone architectural decorations are the most dominant ancient artistic expressions that can be viewed by modern visitors to the ruins of the Byzantine settlements in the Negev Desert (4th-8th centuries CE). The decorated artifacts are made of local raw materials and were probably produced by local craftsman. The reason for the abundance of local craftsman in this region may be related to the massive construction endeavors that took place during the Byzantine period in a previously sparsely inhabited region. The recurrence of the same motifs, throughout all the region of the Levant, firmly connects the inhabitants of the Negev to a more universal Christian tradition. It is the prevalence of the decorations that emphasizes its importance in the daily life of the Byzantine people. The symbolic – apotropaic function of the decorations demonstrates that the ornamentation existed in a realm that transcends a mere aesthetic purpose. This form of art served not only to communicate a religious message, but also as a means of protection that reflected the hopes, and perhaps, fears of the inhabitants of the Negev. In a way, by studying the architectural decorations of the Negev one gains a glimpse into the personal lives of a people living in a newly prospering desert periphery of the Byzantine Empire.

***Tribal towns in the Arabian Peninsula***

**Michael Lecker**, Dept. of Arabic Language and Literature, The Hebrew University, Israel; michaelle@savion.huji.ac.il

The Muslim generals who defeated the great Byzantine and Sassanian empires in the 7th century C.E. were not nomads but sophisticated town dwellers who knew how to rein in the military potential of the bedouin tribes in the service of the conquests. Towns? In the center and the northern part of the Arabian Peninsula? Yes. We know a great deal about Mecca and Medina, but next to nothing about the rest of the Arabian Peninsula. Let us look at one type of towns, namely tribal towns.

***The wanderings in the wilderness according to pseudo-Philo***

**Atar Livneh**, Ben-Gurion University of the Negev; atarlivneh@gmail.com

The wilderness wanderings form the literary framework for a significant part of the Pentateuch. Despite the formal and substantive diversity that exists through Exodus 14 to Deuteronomy 34, the geographical/chronological notations and narratives that reflect the challenges of life in the desert create a sense of literary unity. Pseudo-Philo condenses this extended unit into ten chapters (LAB 10-19), thus omitting many of the biblical passages. This paper examines how the author's selection and rearrangement of the biblical material reshapes the framing narrative. Making very little reference to the wilderness, the act of wandering (e.g., "they had journeyed ... and camped"), or the difficulties



desert life entails (e.g., the lack of water), the theme of the “wanderings in the wilderness” loses much of its force in the post-biblical composition, thereby weakening its role as a unifying device. The literary unity of LAB 10-19 is thus primarily constituted by other means—such as the selection of episodes relating to Israel’s transgression and punishment and God’s everlasting grace.

***The long wall(s) of China: An ecological or cultural marker of the borders between the agricultural region and the drylands***

**Gideon Shelach-Lavi**, The Hebrew University, Israel; gideon.shelach@mail.huji.ac.il

The Long-Wall of China is one of the most celebrated symbols of dichotomy between the sown and the desert. According to this view agricultural societies lived south of the wall while north of it was the land of the pastoral-nomads. In contrast to this monolithic image, historic and archaeological studies shows that the lines of the walls shifted through time, with some of them locating deep inside the steppe area while others are very close to the agricultural heartlands of China. In this talk I will use the history and archaeology of the great walls to analyze the intersection between politics, economy, and ecology in the history of China and the dichotomy created between the Chinese states and their pastoral neighbors.

***The role of the desert in early Egyptian monasticism and Christian hagiography***

**Mark Sheridan**, Pontificio Ateneo, S. Anselmo, Dormition Abbey; mark@dormitio.net

In his Life of Antony, Athanasius wrote that at a certain point, due to the influence of Antony, “the desert became a city.” Because of this literary locus, the desert came to be considered the ideal dwelling place for monks. The literature in turn influenced the development of the notion of “hermit,” which in fact does not belong to the earliest phase of Egyptian or Palestinian monasticism. The earlier use of the word in the Gospels of Matthew and Mark in reference to Jesus being taken to the desert to be tempted also played a role in this development. These literary references to the desert played a considerable role in the development of hagiography in both East and West.

***The Negev in imperial eyes: A frontier between image and reality***

**Yifat Thareani**, Nelson Glueck School of Biblical Archaeology, Hebrew Union College, Israel; tyifat1@gmail.com

In the eyes of the European traveler, desert frontier embodied the dangerous charm of the orient. In the ancient reality however, frontiers often became part of the imperial network adjusted to the needs of trading societies. Thus, the theory, which described an everlasting hostility between the empire and the desert frontier, relied mainly on the simplified acceptance of imperial ideology and on non-critical reading of the historical sources.

This paper elucidates the strategies employed by the imperial power in order to control frontier zones and identifies their archaeological manifestations. It is suggested that the Negev served, during different periods, as a buffer zone, between empires and the tribal desert groups. Empire tended to allow these buffer zones autonomy, without forced settlement of outside populations, and the extent of their influence and culture is revealed in the archaeological record. The empire employed local proxies as agents to further their economic and political interests, a policy that is well attested in the material culture and the annals of pre-industrial empires (Neo-Assyrian, Roman-Byzantine and Ottoman Empires). Interaction with the empire’s exchange system and with their agents stimulated increased social complexity amongst among the local desert tribes.

The prosperous late Iron Age II settlement system of the Negev will use us as a case study.

### ***The ambivalent attitude of Biblical scribes towards the Desert***

**Yonathan Yogev**, Department of Bible, Archaeology and Ancient Near East, Ben-Gurion University of the Negev; baalgev@gmail.com

There is no doubt that some of the most meaningful events in the Bible took place in a desert environment. It seems that although the desert can be regarded as a holy place of epiphany and revelation, it can also be regarded as a cursed place of wild animals, bleakness and death. This duality will be discussed from different angles, and two possible solutions will be suggested that may reveal the many faces of the concept of the desert in Biblical literature.

## **Environmental Education**

### ***Inquiry in science or scientific inquiry: What official documents say and what teachers believe?***

**Nirit Lavie Alon**<sup>1</sup>, Rachel Levin-Peled<sup>1</sup>, Mordechai Aviam<sup>2</sup>, Tali Tal<sup>1</sup>

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What is inquiry? Does inquiry require certain research methods or procedures? Is inquiry limited to the natural sciences? Do journalists, social scientists or archaeologists do inquiry in their practice? There is a current tendency in Israel and worldwide to enhance meaningful learning, inquiry-based learning, developing self-regulated learners and assess student performances based on research projects which become part of the matriculation exams. A huge body of research was published worldwide on inquiry-based learning and on its advantages, such as greater student interest and motivation, deeper learning and even better achievements in standardized tests. On the other hand, the literature points to various challenges in implementing inquiry-based teaching and learning.

The study examines the idea of inquiry as viewed and explained in various documents of the Ministry of Education in Israel and investigates science teacher's conceptions of inquiry. The study also explores the impact of different outdoor inquiry experiences carried out in one semi-arid socio-ecosystem on pre- and in-service teachers' views of inquiry. We assert that participating in a variety of inquiry experiences will develop more complex understandings of what inquiry is and will improve the teachers' tendency and preparedness to employ inquiry-based learning in their classes.

The intervention consist three forms of inquiry: in ecology, in archeology, and in the social sciences. Each experience includes a one-day field investigation, which is supported by preparation and summary activities provided online.

The analysis of documents developed by the Ministry of Education and documents posted in different educational websites that deal with the nature of the inquiry, reveals varied pictures: different definitions, modes of reference, and various procedures; for example, confusion regarding research genres and their definition of scientific/empirical/ qualitative/quantitative research. We identified insufficient acknowledgement of the adequacy of different genres with respect to what is described as scientific inquiry and inadequate reference to the contribution of different methodologies to the ability to address different research questions.

Analysis of 54 preliminary questionnaires that were distributed among the teachers reveals different perceptions and reflects ambiguity. Most respondents had a broad perspective of inquiry as any systematic investigation of a research question. Some expressed a limited view of scientific exploration as such that applies only to the natural sciences. Observations during the field exploration activity indicate much interest among teachers and that a systemic discussion related to ecology, society, and archeology encourages meaningful discourse of inquiry.

***Construction of new sense of place in an unrecognized Bedouin village***

**Noa Avrieli-Avni**, Dead Sea and Arava Science Center, noa@adssc.org

The study focuses on a Bedouin village in the Negev Desert of Israel. In the early 1980s, the Bedouin shepherds were forced to stop their seasonal migration in the region considered as their homeland, and turned to be permanent inhabitants in a place where they develop a sense of social and geographical alienation. Five years ago, a small group of men was organized to give the village a new identity as an educational center of Bedouin Desert Culture. During this process the men were required to recount their far past as nomads, to confront their more recent past as illiterate people, and to weave a dream about a new personal identity as the owner of valuable knowledge about desert sustainability.

Narrative analysis of a series of in-depth interviews that were made with the leaders of the initiative allows us to identify a formulating a new sense of place and reveal its complex components. For the narrative analysis, we used the theoretical framework of Space and Place, which perceives reality as a product of interaction between the actual space, the imagined space and the symbolic space.

The analysis demonstrated that as the imagined space evolved--the dream of the village as an educational and tourist center--the men approached the elders with a request for information about the shepherds' tradition, which was almost forgotten at this time. Thus began to expand also the symbolic space. As a result, the actual space of the unrecognized settlement, which previously had a major and depressing presence in their lives, received a more balanced proportion. Their sense of place was strengthened and their place identity became a more positive one. In many aspects of the Bedouin Desert Culture center establishment were involved Jewish members. The analysis of the leaders' narratives addressed the potential of neo-colonialist effect of this involvement and indicates points where care must be taken.

Understanding this case study of narrating identity formation can refine our ability of nurturing sense of place in people that disconnect from the environment in which they grew up and move, voluntary or forced, to new places.

***This road is in my space-map - Highway 31 as a place in the Israeli Negev***

**Arnon Ben-Israel**, Ben-Gurion University of the Negev, arnonbe@bgu.ac.il

In this paper we integrate a theoretical theme with a description of idiographic reality in the Negev. First, we argue that roads, routes, paths and the like are places in the full sense of this term, as are settlements; they are spaces that people tend to load with meanings and significance. Although this argument may sound trivial to the popular ear, it somehow undermines the instrumentalist and technologist bias which have characterized the traditional scientific geographic discourse of roads as spatial entities. We will demonstrate this theoretical argument by exploring several layers of meanings that have been constructed by the Bedouin who reside along Highway 31's margins in the northern Negev. Images, memories, emotions, and concepts--- all are entwined by Highway 31 in the Bedouin's sense of place drawing a spacio-mental range whose poles are death, disaster, and discrimination at one edge and social encounters and sense of history, continuation, and belonging at the other.

***(De)centering the margins: The role of environmental education in facing the challenges of desertification***

**Annette Gough**, RMIT University, Australia, annette.gough@rmit.edu.au

Environmental education and combatting desertification share a longstanding focus on achieving sustainable development. Environmental education has been recognised as critical for achieving environmental awareness, values and attitudes, skills and behaviour consistent with sustainable development and for effective participation in environmental decision making. Since at least the Declaration of the 1972 United Nations Conference on the Human Environment, environmental education has been recognized, and desertification has been identified (along with climate change and the loss of biodiversity) as the greatest challenge to sustainable development since the 1992

United Nations Conference on Environment and Development. They also share a need to work with marginalized and silenced groups in society to encourage their participation in environmental decision making.

This presentation discusses how desertification can be incorporated into environmental education in schools as part of a bottom-up approach to encourage the participation of local people in combating desertification and land degradation, consistent with the UNCCD mission. It will also discuss how desertification is often the concern of marginalized peoples, how it is marginalised in school education, and how it needs to embed school education in its action plans.

Particular questions to be addressed in this context include: who should be educated, about what, where, and with what goals in mind?

No abstract.

### ***Hebron Stream as a place identity component for primary school students living in nearby Bedouin communities***

**Wisam Sedawi**, Ben-Gurion University of the Negev, wisams@post.bgu.ac.il

This study addresses the manner in which primary school children in the Bedouin community experience Hebron Stream and its environment, specifically how they perceive the stream as a component of their place identity and their connection to nature. The students' familiarity with the ecological space of Hebron Stream is based in their daily lives, due to the stream's proximity to the settlements where they live.

Hebron Stream is currently a real environmental hazard, a source of harm to the population that resides nearby. It is contaminated with urban and industrial sewage originating in the nearby Palestinian cities and Jewish settlements, as well as runoff from quarries and lumber mills. In addition to the variety of plant life that is fertilized by the sewage runoff, the streambed is littered with mounds of solid waste.

Data for this study was collected according to the qualitative approach. It consisted of two stages. First the students were asked to draw two pictures, one depicting "my village" and the other "Hebron Stream." In the second stage, we conducted a semi-structured interview with the students, discussing elements from their drawings and their perceptions of the stream and its natural environment.

Our results indicate that the students have a distinctly negative attitude towards Hebron Stream. Their drawings and interviews reflect an external viewpoint, according to which the stream is not a component in their place identity. Furthermore, the students do not view the stream as a natural resource, but rather as a place in which to dump garbage. The students' interviews did reflect an appreciation for their natural landscape and environment in other contexts, such as the fallow field in their village, which contributes to their perception of enjoying nature. All students showed empathy and care for the animals they raise (e.g. goats, sheep), though some also admitted breaking the eggs in the nests of birds found near the streambed.

Our results emphasized the need for developing a model of place-based environmental education to develop a place identity and a connection to nature among students. Making the stream a firmer part of the local community's place identity may strengthen its willingness to take a more active role in conserving it as a local natural and scenic resource.

### ***Collaboration of multicultural knowledge through Communication Technology - understanding the social-ecological coupled systems of the desert***

**Lior Solomovich**<sup>1</sup>, Noa Avriel-Avi<sup>2</sup>, Avinoam Meir<sup>3</sup>, Gilad Ravid<sup>4</sup>

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The term "Social-Ecological Coupled System" (SECS) reflects the perception of the environment as an open, complex and dynamic system that requires constant learning and adaptation of human behavior to maintain its resilience.

The ASAM (Human & Environment in the Desert) project is a network of schools, currently including 10 schools from the Jewish and Bedouin populations in South Israel. Each school becomes a long-term research site that investigates its local SECS.

The teaching staff participating in ASAM is characterized by a high variety of cultures, languages, religions, socio-economic level and environmental attitudes. The study follows the formation of the teachers' community of practice by mixed, quantitative and qualitative methods. It highlights the interactions, competencies, and relationships that are formed in multicultural collaboration of knowledge through communication technology.

The term “multicultural collaboration” is defined as the exchange of opinion, information-sharing, and mutual acknowledgement within a commonly understood framework for participation. The computer networking enables the teachers to share local knowledge and to receive professional support from colleagues and academic researchers. The main challenge facing the community refers to the complexity of collaboration, mutual learning and creating knowledge which were developed during the online synchronous discussion. This challenge is complex because of the composition of the teachers and the use of technology as a main tool for communication.

There are several notable difficulties that were encountered. For example, most of the Jewish participants did not want to involve political discourse in environmental discourse and they would not discuss their political opinions freely because they did not want to offend Bedouin participants. Another difficulty for mixed couples was to find a common research question because of differences in culture and geography. For example, teachers from Segev Shalom and Ein Gedi who tried to formulate the same research question, found they had difficulty due to differences.

The analysis of the online synchronous conversations emphasizes the importance of a collaborative process of ideas and dialogue in a culturally diverse society. Teachers who participate in the program are exposed to new ideas and well recognized its value in meeting their needs for ongoing access to information and community. The program allows them new forms of participation, upgrading of skills, increased productivity, development of a new learning culture, and the exchange of creativity, information, and dialogue. Despite its difficulties, learning together creates a wider base of wise management of the desert-SECS.

### ***Learning about the desert or about the coast line: A dichotomy or a continuum?***

**Tali Tal**, Technion – Israel Institute of Technology; rtal@technion.ac.il

Desertification is a good example for human-induced impacts on the environment with which environmental education (EE) addresses. In fact, a major expectation from EE is to deal with local ongoing processes and problems that our society confronts. My belief is that students should learn about local issues and develop deep understanding that will further allow them to understand global issues as well. Such learning should encompass classroom and out-of-school learning, and should involve the larger community and its institutions as well. One of the major discussions in the area of EE is whether it should be an independent field of study, with central (national) curriculum development. Alternatively, EE could remain voluntary, place-based and school-based. The idea I wish to put forward is that EE should be both. It should be recognized as a mandatory field of study and include core ideas and practices, but it should and could remain with its local characteristics, so that a student in the Negev desert will address more with desertification, and a student living in the coast area will be engaged more in the discussions over the conservation of the natural Mediterranean coast habitats versus additional economic development of the coastal areas. I believe that by addressing closer and better known systems, and by debating over more relevant topics, students will develop deeper knowledge and thinking.

## Family Planning and Development in Drylands

### *Status of women, sustainable forestry and family planning in Kenya*

Jane Mutune; Greenbelt Movement

### *Pronatalism as cultural worldview: An important challenge for environmentalists and advocates for lower population*

Michele Rivkin-Fish, Department of Anthropology, University of North Carolina, Chapel Hill; mrfish@unc.edu

In his forthcoming book, *The Land is Full*, Alon Tal urges Israeli policy makers to abandon their long-standing commitment to population growth in light of the severe ecological, political, and social costs this growth is incurring. In a broader world context where concerns over population growth have been largely eclipsed by preoccupations with development, reproductive health or rights, and the problems of aging populations and dependency ratios, Tal's argument does important work to revive the debate over the negative consequences of population growth. The current paper examines some of the challenges Tal's argument raises for scholars and activists working globally to critique pro-growth and pronatalist ideologies. Specifically, the paper demonstrates how, in societies that embrace pronatalist thinking, pronatalism is more than an orientation to public policy; it is a powerful cultural worldview about governance. Drawing on the case of pronatalism in Russia, I sketch this cultural worldview as residing in: a vocabulary that establishes a particular vision about family, gender, and personal happiness; an affective structure of emotions--specifically, patriotic affect-- that builds on broader fears that the nation is under siege and its future continuity must be secured; and a historically-rooted, moral understanding of state-citizen relations that obligates the state to provide welfare and support for families. These visions, variously presented by experts, journalists, and politicians, dominate discussions pervading the public sphere about the state of society at present, as well as forecasts of its future. Even where individuals resist explicit state intervention into their reproductive decisions and insist on preserving sexuality and reproduction as a sphere of "privacy," key aspects of pronatalist thinking and culture may shape their political inclinations, such as on issues regarding state support for families and childbearing. In pronatalist societies like Israel and Russia, promoting a reorientation of public policies away from supporting fertility growth will require extensive, wide-reaching transformations of the culture of pronatalism, including its nationalist underpinnings, its anti-liberal sensibilities, and its complex ties to social welfare.

### *Comparing the Drivers Behind Differential Birth Rates in Israel*

Alon Tal, Blaustein Institutes for Desert Research, Ben Gurion University; alontal@bgu.ac.il

Desertification is just one of the many environmental impacts caused by excess population pressures. While Israel has taken important measures to reduce land degradation, its dramatic demographic growth is manifested in myriad hazards. Improved soil health is also undermined by the heavy footprint of burgeoning human settlement. Understanding the reasons behind this increase is important for assessing future trends and their likely impact on natural resources.

Israel's population has indeed expanded nine-fold since its establishment in 1948: from one to nine million people. For much of the country's history, immigration constituted the primary engine for demographic growth. Over three million immigrants moved to Israel during its first sixty years. But during the past decade, the rate of immigration has fallen due to numerous factors in the Jewish world. Large families and population momentum have emerged as the cause of the country's high annual growth rate of 1.8%. But birth rates within Israeli society are anything but uniform. While some communities in Israel have seen a dramatic drop in fertility levels, others continue to have extremely large families.

For many years, the fastest growing segment in Israel's population was the country's Arab citizens. This phenomenon reached a peak during the 1960s with the Arab Total Fertility Rate reaching 10 children per family. Moreover, during

this time, birth rates among different segments of the Arab-Israeli population were indistinguishable. Yet, in a swift but steady process, the TFR among Israeli Arabs dropped to roughly 3. Birth rates also show dramatic differences between diverse Arab ethnic groups: for instance Christian Arab populations exhibit a replacement population rate of 2.1 and the Druze have dropped to 2.26.

During the 1950s and 1960s, the population rates amongst Israeli ultra-Orthodox “Haredi” Jews were comparable to other Jewish communities in Israel and did not exceed a TFR of three children. This began to change as the government’s pro-natal policies were implemented during the 1970s. Payment of child allowances and birth grants, discounts in taxes, reduced expectations for military service, prioritization in public housing and facilitation of early marriages combined to create a power subsidy package for this community which was already predisposed to encourage multiple births. On average, Haredi parents have over six children, more than twice the national average of 2.8 children per family, and many have ten or more offspring. In 2010, the Central Bureau of Statistics reported that Haredi Jews in Israel are increasing at a rate of 6% a year, more than three times the societal average.

Among the reasons for the different responses to Israel’s “pro-natal” policies among the Arab and Haredi communities are:

1. Gender roles and expectations from women and wives in the different societies;
2. Contrasting “Israelization” processes, reflecting inclinations to integrate into Israeli society;
3. Religious dogma and the greater tolerance to family planning among the Muslim and Christian religious leadership than the ultra-Orthodox, where pro-natal doctrines are promoted;
4. The effect of recent regional trends in family planning the Middle East; and
5. The different attitudes and responses to pro-natal, economic incentives.

Population growth in Israel has not been widely recognized as a critical indirect driver of land degradation and other environmental problems. Because population stability is a critical prerequisite for a sustainable future, Israel must adjust its demographic policies so that government interventions resonate throughout the country’s multi-cultural demographic mosaic and influence family planning decisions across society.

## Geological Aspects of Deserts and Desertification

### *Life on rock – Rock outcrops as key component of the natural and human systems in the arid and semi-arid Areas*

**Oren Ackermann**<sup>1,2</sup>, Mordechai Haiman<sup>1,3</sup>, Helena M. Zhevelev<sup>4</sup>, Tal Svoray<sup>5</sup>

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Arid and semi-arid areas have limited water conditions. These conditions are the limiting factor in the landscape ecological systems in these climate zones. However, both natural and human ecosystems exist in these areas. This lecture will discuss the existence of such systems in two areas in Israel: the Judean Shephelah, which is under semi-arid conditions (300-400 mm annual average rain), and the Negev Highlands, which is under arid conditions (~100 mm annual average rain).

The surface in the Judean Shephelah is characterized by alternating rock outcrop and soil pockets. The rock outcrops act as a source for runoff which is absorbed in the soil pockets, which act as sink. Therefore, areas below rock outcrops are under enhanced water conditions.

Field surveys conducted in the Judean Shephelah revealed a strong relationship between the distribution of the natural vegetation and rock outcrops. Rocky surfaces allow for heterogeneous vegetation with a high presence of shrub while

non-rocky surfaces have a homogeneous (80%) cover of the lower shrub known as thorny burnet (*Sarcopoterium Spinosum* L.).

Additionally, agricultural terraces were observed both on the slopes and in the valleys located at the foot of rock outcrops. These terraces received a high amount of runoff generated on the rocky surface.

In the transition to the arid zone of the Negev Highlands, the surface is composed mostly of rock fragments and large rock outcrops. This surface generates runoff that is absorbed in the valleys at the foot of the slopes. Under these conditions, both natural vegetation and agricultural terraces are concentrated in the valleys only.

In conclusion, rock outcrops in the arid and semi-arid zones play a significant role in both natural and human systems.

### ***Pedogenesis in response to Quaternary-scale aridification of the Negev desert, Israel***

**Rivka Amit**<sup>2</sup>, Y. Enzel<sup>1</sup>, O. Simhai<sup>1,2</sup>, A. Matmon<sup>1</sup>, N. Porat<sup>2</sup>

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Although wetter Quaternary episodes were suggested for the Negev desert, we demonstrate that Reg soils on flat, stable alluvial surfaces, sensitive to minor changes in precipitation, indicate that the southern Negev has been hyperarid throughout the Quaternary. Tectonically stable, well-preserved Pliocene alluvial surfaces of the Paran watershed (southern Negev) allowed continuous development of cumulative-welded soils. The determination of the in-situ <sup>10</sup>Be and <sup>36</sup>Cl activities in the desert pavement, and alluvial parent material of these ubiquitous Near East surfaces allowed the bracketing of the age of their formation and abandonment. The chert clasts of the desert pavement are 1.5-1.8 Ma with maximum possible extremely slow erosion rates of 2-5 cm Ma<sup>-1</sup>. The complex soil profiles started to develop after ~1.9 Ma with moderately developed calcic soil at ~1 m depth, later change to gypsic and gypsic-saline soil. Regionally, the gypsic-saline soil developed since at least 300 ka (OSL ages) and is associated with massive dust accumulation. This pedogenesis indicates transition from semi-arid Plio-Pleistocene to arid early Pleistocene and extremely arid conditions since at least the middle Pleistocene. At the same time calcic soils (stage V-IV) formed in the northern Negev. This indicates that the proposed wetter episodes were restricted to the northern Negev, currently mildly arid (100-250 mm yr<sup>-1</sup>). This steep gradient in the Negev paleoclimate and the permanency of the southern Negev Quaternary hyperaridity is explained by the main control over the regional rainfall: the southward-decreasing depth of the atmospheric boundary layer with distance from the Mediterranean, the altitude of the central Negev Highland (1000m) and the location of the southeastern Mediterranean shoreline. Their interaction prevents or allows the passage of rain clouds into the southern Negev. We suggest that hyperaridity has prevailed over the southern Negev since the last stages of the uplift of the central Negev Highland during in the late Pliocene-early Pleistocene. We also demonstrate that climatically, the Negev desert is not a simple extension of the Sahara, with which the Negev is frequently associated.

### ***The geological background of desert environments in the Middle East: timing, processes and future predictions***

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Located on the northern edge of the global desert belt, the Middle East deserts offer perfect study sites for revealing the geological history of desert environments. Fine-grained sediments and coarse conglomerates are found in Israel in the Arava Formation of Pliocene to Early Pleistocene age. These alluvial sediments, originating from desert dust and from exposed geological sections, cover vast areas in southern Israel, eastern Sinai and southern Jordan. These types of alluvial sediments are clear indicators of the desert environment that prevailed in the Middle East for the last 2 million years. Similar components are found in fluvial terraces deposited in these areas during the Pleistocene, best preserved in lowlands and topographic depressions such as Wadi el Arish in Sinai, the Paran and Zin drainage basins in the Negev and in Wadi Araba and its tributaries in Jordan. Of all the sediments, the best preserved are those deposited during the last 100,000 years representing a complete cycle of interglacial-glacial shifts, including the beginning of the present interglacial. The previous interglacial phase is represented by a basal conglomerate of coarse pebbles derived from local rock sources, resulting from high energy desert floods that eroded the exposed rocks in the drainage basins. These conglomerates are covered by fine alluvial sediments composed of desert dust, brought to the



region mainly from the eastern Sahara Desert, combined with local dust and some pebbles originating from local desert environments. The exact timing of deposition was determined by OSL to range between 71 and 24 ka. After major phase of deposition under semi-arid climate, erosion started to take over during the last glacial – interglacial transition, first along the mountain slopes (24-17 ka) and afterwards forming initial gullies in the valleys (post 10 ka). The gradual development of gullies during the Holocene contributed to massive erosion of the fine sediments deposited during the previous stages. As most of the natural biomass and the agricultural potential are very much dependent on these sediments, this process has been increasing desertification within desert environments. Future predictions indicate that most of the desert environments of the Middle East are being gradually transformed into rocky environments with low biomass and species diversity and low agriculture potential, but with higher productivity of runoff. All these are clear indications of natural desertification that is speeding up in non-linear rates. Similar processes are active in other desert environments world-wide.

### ***Sand dunes and the downwind accretion of desert loess***

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Loess is a widespread eolian deposit dominated by coarse silt-sized quartz particles, and serves as an important archive of information on Quaternary climate change. In addition, high rates of loess accumulation can lead to hydrological changes, in terms of runoff generation and infiltration rates, and can lead to changes in soil erosion rates. Despite the intensive research during the past century on desert loess formation, its origin remains poorly understood and is still a fundamental problem in sedimentology and in Quaternary paleoclimatology. Here we adopted a global view to examine desert loess sources and to suggest possible processes for the formation of coarse silt grains in loess. We examined, in detail, several well-known late Pleistocene loess regions in different subtropical deserts (North Africa, The Sahel, Middle East and Arabia) and found that all these loess regions are located downwind of adjacent sand seas. Together with evidence of mineralogical similarity between the loess and the sand dunes and their contemporaneous activities, these observations suggest that sand seas are an important source for desert loess. Since there is only limited silt grain storage in sand dunes, we postulate that the silt grains comprising most of the loess are not reworked from the dunes but are generated probably through active eolian abrasion of the medium sand grains under past climates characterized by intensified winds. As a result, the role of sand dunes and eolian abrasion in formation of desert loess can be more important than previously thought.

## **Kidron River Restorations**

### ***Searching for Environmental Dignity in the Kidron/Nar Basin***

The Kidron Valley/Wadi Al Nar meanders from Jerusalem through the Judean Desert to the Dead Sea. Some of the world's most famous cultural, religious and historic sites dwell in harmony in the valley, along with ancient tombs, underground watercourses, monasteries and breathtaking desert landscapes. Unchecked development and neglect, however, together with an increase in population, has had major health, environmental, and economic consequences. Today one of the great centers of civilization serves as a conduit for raw sewage and a depository of solid waste. The Kidron/Nar Master Plan, completed in 2012, identifies the issues, concerns and problems of the basin and recommends solutions. A Master Plan, based on ecological, historical, physical, economic and geographical terms agreed upon by both sides will serve the best interests of the Valley, regardless of present or future political sovereignty issues. There is no alternative to collective action when managing a shared international basin. Today the Master Plan is being implemented through an Implementation Plan, with several projects in the areas of environmental education, solid waste management, water and sewage treatment, scientific initiatives and more being developed.

## **Math Sessions: Ecohydrology of Dryland Landscapes; Mathematical Aspects of Desertification; Dryland Landscapes as Pattern-forming Systems**

### ***Rainfall-infiltration-runoff relationships in a semi-arid hillslope and their interactions with vegetation cover***

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The hydrological response of semiarid watersheds to rainfall events is complex due to feedbacks between water fluxes, vegetation patches, topography, and soil properties. This paper investigates the combined impact of rainfall intensity, infiltration contrast between bare and vegetated areas, horizontal extension of the root zone beyond the canopy size, slope steepness, and vegetation cover on surface hydrological processes in a semiarid hillslope. Two modeling approaches are applied to study the related rainfall-runoff relationships: a simple analytical model and a two-dimensional numerical model coupling between surface runoff and infiltration. Results indicate that the infiltration contrast is the predominant factor allocating additional water to the local vegetation.

### ***Critical and gradual transitions in spatially extended ecosystems***

**Golan Bel**<sup>1</sup>, Ehud Meron<sup>1,2</sup>, Yuval Zelnik<sup>1</sup>, Shai Kinast<sup>1,3</sup>, and Hezi Yizhaq<sup>1,4</sup>

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Critical transitions have attracted a great deal of attention due to their relevance to many natural and social systems. Much research has been devoted to the characterization and identification of imminent critical transitions. In spatially extended systems, the dynamics (close to and away from the critical point) are more complicated due to the expansion, shrinking and coalescence of alternative-state domains. Pattern-forming systems introduce additional complexity due to the patterned nature of one of the stable states. In this talk, I will present several works in which we used the context of dryland vegetation dynamics to study various aspects of this additional complexity: (i) The existence of localized states and their effects on regime shifts in models for the dynamics of dryland vegetation and the response of the systems described by these models to local perturbations will be discussed. (ii) We show how a simplified version of a model for dryland vegetation dynamics can explain the emergence and the observed dynamics of the spectacular phenomenon of “fairy circles” in southern Africa. (iii) If time permits, I will present recent results demonstrating the effects of heterogeneity on the pattern formation, survivability and resilience of water-limited vegetation.

### ***Early-warning signals for desertification: a percolation framework***

**Anna Maria Cherubini**, University of Salento and Imperial College, London, UK

(Joint work with Raffaele Corrado and Cecilia Pennetta, Dipartimento di Matematica e Fisica, Università del Salento, Italy)

We present the results of a theoretical study on the desertification transition in semi-arid ecosystems, aimed at identifying early transition indicators related to the time fluctuations of the vegetation patterns. To this purpose we performed numerical simulations based on a stochastic cellular automaton model for semi-arid ecosystems recently introduced in literature and we analyzed the results in terms of percolation theory, focussing in particular on the role played by the mortality rate  $m$  related to the strength of external stresses acting on the system. For increasing values of the mortality rate  $m$ , related to the strength of external stresses acting on the ecosystem, we could follow its increasing degradation through different stages, characterized by different connectivity properties, up to the critical transition corresponding to the extinction of the vegetation and almost complete degradation of the soil, occurring at a critical value  $m_c$ .

In order to find suitable indicators and precursors, we calculated the spanning probabilities and the percolation thresholds as functions of  $m$  according to different spanning criteria and we studied the time fluctuations of the sizes of the biggest vegetation cluster and the biggest non-vegetated cluster over the range of mortality values. The dependence of  $m_c$  on other parameters of the model (corresponding to ecological mechanisms such as facilitation) is studied as well.

### ***Competition of species using a synthesizing unit approach***

**Ulrike Feudel<sup>1</sup>, Partha Sharathi Dutta<sup>1</sup>, Bob W. Kooi<sup>2</sup>**

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In many studies of competition models, Liebig's law of the minimum is used to account for the fact that the least available nutrient will determine the growth rate of the plankton species. However this would require that the organisms can instantaneously switch their physiological regulation system, which is problematic. It is more natural to assume that there is a co-limitation for all resources, so that all resources contribute to the growth rate. Therefore we study models which use the concept of a synthesizing unit developed in the framework of energy budget theory. This concept is based on the mechanisms of enzyme kinetics and considers all resources as complementary. Using this model we study the dynamics of the competing species which can exhibit competitive exclusion, heteroclinic cycles, stable coexistence in a fixed point and periodic solutions. Moreover, we find the coexistence of more species than resources in parameter regions where periodic and chaotic solutions are possible. Hence we can show that supersaturation is possible in a model with a more realistic approach to the uptake of resources. It is important to note that this model exhibits supersaturation in parameter ranges which are realistic. Our study reveals the dynamical mechanism how supersaturation can occur: it is due to a transcritical bifurcation of limit cycles.

Furthermore, we show how general competition theory can be explained in terms of bifurcation theory to account for a much larger class of systems than originally studied by Tilman. This mathematical approach complements and extends the graphical methods developed by Tilman to include models with co-limitation and with a larger number of species.

### ***Adopting a spatially explicit perspective to study the mysterious fairy circles of Namibia***

**Stephan Getzin, Helmholtz Centre for Environmental Research-UFZ, Germany**

The mysterious 'fairy circles' are vegetation-free discs that cover vast areas along the pro-Namib Desert. Despite 30 years of research, their origin remains unknown. Here we adopt a novel approach that focuses on analysis of the spatial patterns of fairy circles obtained from representative 25-ha aerial images of Northwest Namibia. We use spatial point pattern analysis to quantify different features of their spatial structures and then critically inspect existing hypotheses with respect to their ability to generate the observed circle patterns. Our working hypothesis is that fairy circles are a self-organized vegetation pattern. Finally, we test if an existing partial-differential-equation model, that was designed to describe vegetation pattern formation, is able to reproduce the characteristic features of the observed fairy circle patterns. The model is based on key-processes in arid areas such as plant competition for water and local resource-biomass feedbacks.

The fairy circles showed at all three study areas display the same regular spatial distribution patterns, characterized by Voronoi cells with mostly six corners, negative correlations in their size up to a distance of 13 m, and remarkable homogeneity over large spatial scales. These results cast doubts on abiotic gas-leakage along geological lines or social insects as causal agents of their origin. However, our model was able to generate spatial patterns that agreed quantitatively in all of these features with the observed patterns. This supports the hypothesis that fairy circles are self-organized vegetation patterns that emerge from positive biomass-water feedbacks involving water transport by extended root systems and soil-water diffusion. Future research should search for mechanisms that explain how the different hypotheses can generate the patterns observed here and test the ability of self-organization to match the birth- and death dynamics of fairy circles and their regional patterns in the density and size with respect to environmental gradients.

### ***Climate changes in precipitation variability and dryland vegetation***

**Jost von Hardenberg**, Institute of Atmospheric Sciences and Climate – CNR Turin, Italy

Global and regional climate modeling results indicate possible future changes in precipitation regimes in several regions, with possible modifications in the amplitude distribution, in the frequency and in the spatial and temporal patterns of precipitation. While great uncertainty affects these projections, such changes have the potential to impact significantly on the functioning and biodiversity of many ecosystems, particularly for water-limited ecosystems. For example, mathematical modeling of dryland vegetation has confirmed that spatial and temporal precipitation variability favour the survival of vegetation also under extreme dry precipitation conditions. Several manipulative experiments are currently being designed and implemented with the aim of analyzing the impact of possible future changes in the temporal distribution of precipitation. The experimental design, such as in the case of rainout shelter experiments aimed at reproducing drought episodes, may have unintended effects such as a reduction of precipitation variability and may not allow reproduction of long-term inter-annual variability. I will discuss and illustrate some of these topics, also considering results from simple mathematical models for dryland vegetation.

### ***Reversing desertification: less is more***

**Ehud Meron**<sup>1,2</sup>, Yair Mau<sup>2,3</sup> and Lev Haim<sup>2,4</sup>

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Self-organization processes leading to pattern formation phenomena are ubiquitous in nature. There is increasing observational evidence that pattern formation also plays an important role in shaping water-limited landscapes. Depending on the rainfall regime, self-organized vegetation patchiness in the form of nearly periodic spot, stripe and gap patterns has been reported. Supporting these observations are studies of spatially explicit vegetation models that have reproduced many of the observed patterns. These models lend themselves to the powerful methods of pattern formation theory, and can be used to gain deeper understanding of vegetation restoration in degraded landscapes. Vegetation restoration is often based on periodic ground modulations that intercept overland water flow and form favorable conditions for vegetation growth. Viewing this method as a spatial resonance problem, we show that plain realizations of this method, assuming a complete vegetation response to the imposed modulation pattern, suffer from poor resilience to rainfall variability. By contrast, less intuitive realizations, based on the inherent spatial modes of vegetation growth and involving partial vegetation implantation, can be highly resilient and equally productive.

### ***Wavelength selection and hysteresis in mathematical models of banded vegetation***

**Jonathan Sherratt**, Heriot-Watt University, UK

Spatially patterned vegetation is a characteristic feature of semi-arid ecosystems, and provides a classic example of self-organised pattern formation. Because of the geographical remoteness and physical harshness of study sites, and the long time scales involved in pattern evolution, mathematical modelling has emerged as an important research tool. A number of established models are based on the "water redistribution hypothesis", and I will present detailed studies of two such models, due to Klausmeier (Science 284, 1826-8, 1999) and Rietkerk (Am. Nat. 160, 524-530, 2002). I will discuss the bifurcation analysis of "periodic travelling wave" patterns, which correspond to banded vegetation on hillsides. My results enable prediction of the tipping point at which rainfall levels become too low to support any vegetation. I will also show that for a given rainfall level above this critical value, there is a family of possible patterns, with different wavelengths. New numerical methods for calculating pattern stability show that although some of these patterns are unstable as solutions of the original model, there is a range of wavelengths for which the patterns are stable. This raises the possibility of hysteresis in properties such as wavelength as the annual rainfall varies. I will demonstrate this in model simulations, showing that there are a series of tipping points at which there are sudden shifts in pattern wavelength, and which can be predicted using the results of my bifurcation analysis. Finally, I will combine my various results to derive a simple formula that predicts the wavelength that will develop when there is a switch from homogeneous to patterned vegetation due to a decrease in annual rainfall.

### ***Stochastic desertification***

**Nadav Shnerb**, Bar-Ilan University, Israel

The process of desertification is usually modeled as a first-order transition, where a change of an external parameter (e.g. precipitation) leads to a catastrophic bifurcation followed by an ecological regime shift. However, vegetation elements like shrubs and trees undergo a stochastic birth-death process with an absorbing state; such a process supports a second-order continuous transition with no hysteresis. I will present a study of a minimal model for first-order transitions with an absorbing state. When the external parameter varies adiabatically the transition is indeed continuous, and the data reflecting the mid-Holocene desertification of the Sahara appear to support this scenario. The front velocity renormalizes to zero at the extinction transition, leaving a finite "quantum" region where domain walls are stable and the desertification takes place via accumulation of local extinctions. A catastrophic regime shift may occur as a dynamical hysteresis if the pace of environmental variations is too fast.

### ***Modeling power-law edge-interior area decline in shrub and soil patch patterns along a climatic gradient***

**Maxim Shoshany**, Mapping and Geo-Information Engineering, Faculty of Civil & Environmental Engineering, Technion - Israel Institute of Technology, Israel

Variations in shrub and soil patch pattern properties along climatic gradients between Mediterranean and arid ecosystems represent, to certain extent, these ecosystems' response to future climate changes. Modeling changes in patch pattern properties may, thus, be instrumental in better understanding the future consequences of land degradation of desert fringe ecosystems due to global warming and continuation of human disturbance. Edge effects on plant properties in arid and semi-arid regions concern water losses and growth inhibition, which gradually decreases towards the deep core areas of vegetation patches. Warming and overgrazing cause patches to be smaller and narrower, resulting in higher edge effects, and this is well represented by patch pattern properties along the gradients.

It is hypothesized here that the rate of edge-interior area decline follows a power-law. Based on high resolution imagery, this hypothesis was assessed at 52 sites between Zecharia (530 mm/year rainfall) and Lehavim (250 mm/year rainfall).

The model: Area of inner zone =  $b \times e^{\text{Edge effect} \times \text{Distance of zone from the patch boundary}}$  was found most statistically significant for all sites, both for the soil and plant patches. The **Edge Effect**, which is the empirically-derived coefficient, using a linear regression of the Ln-Ln form of this equation, represents the rate of Edge-interior area decline. While Edge effects for vegetation patches generally increased with decreasing rainfall, edge effects within bare soil patches

decreased. The two edge-effect coefficients represent new pattern parameters that not only contain information regarding the plant-soil structure, but also are of close affinity with the modes of evolution of those patterns, and with modes of future response of desert fringe ecosystems to climate change and human disturbance. Implementation of this approach, along the climatic gradient, allowed generalization of a mathematical model describing the link between rainfall, shrub cover fraction, and the two new edge effect coefficients. This model may offer an estimation of patch pattern changes in response to desertification in vast, semi-arid to arid transition zones.

### ***Relationships between primary productivity and rainfall in a semiarid ecosystem***

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Walter's two-layer model and the rainfall pulse hypothesis constitute the theoretical basis for our research on the use of rainfall water by different vegetation types in drylands. The two-layer hypothesis assumes that soil water storage determines vegetation productivity in dry environments while the rainfall pulse hypothesis assumes that only biologically meaningful rainfall events do so. Here we study the effect of rainfall characteristics and topographic and surface variables on soil water dynamics on a semiarid hillslope at Lehavim LTER in the northern Negev, Israel. The Hydrus 2D model was applied to a spatially and temporally explicit database of the hillslope to study water availability to herbaceous vegetation and dwarf shrubs in this environment. Results are analyzed to: (i) explore how the two different vegetation types respond to rainfall pulses; (ii) study water budget in the root zone to confront the two hypotheses; and (iii) study the effect of topographic and surface characteristics on water budget in the root zone.

## **Nutritional and Food Security**

### ***A Global Food System without Food Reserves: A Recipe for Disaster***

**Hendrik J. Bruins**, Ben-Gurion University of the Negev, Jacob Blaustein Institutes for Desert Research, Swiss Institute for Dryland Environmental and Energy Research, Bona Terra Department 'Man in the Desert', Sede Boker Campus, Israel

Throughout history, from antiquity to the recent past, food grain reserves were considered a rather common insurance policy to cope with unpredictable crop failures. Both the public and private sector tried to build up and maintain food reserves, as proactive contingency planning. Hunger was the most frequent cause of popular revolts and governments were keen to have food reserves for humanitarian reasons, good administration and public stability.

The industrialization and globalization of the food market since the Second World War led to agrarian and social changes unprecedented in the entire history of humanity. The large food grain reserves held by the governments of the United States and Canada during the 1950s and 1960s no longer exist. Alternative food policy views developed during the 1970s led to the abandonment of public food grain reserves in North America and elsewhere. Economists in the 1970s advised governments to do away with food reserves, arguing that it is cheaper to have money reserves in the bank to purchase food than to store actual food in silos, where it may get spoiled. Such economic and food policy views, presented as good for global trade and a more integrated world, won the day. Hence we live today in a world without any substantial food reserves, with the noted exception of China.

The great variety of food products in the supermarkets, from all over the world, gives a false sense of security. The global food system is very complex and non-transparent. Most nations are dependent on food grain imports. The total volume of food grains annually available on the world market cannot buffer a major shortfall in food production. There are no significant food grain reserves in the world, only carryover stocks. Hence mega-crises are likely to develop in the near future, characterized by major food shortages, steep price rises and even famine on a large scale, triggered by hazards such as drought, bad weather and other contingencies, i.e. unforeseen negative developments.

***On-farm performance of three elite sweet potato varieties at Mukuyuni in Makueni County in semi-arid eastern Kenya***

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An adaptive study of sweet potatoes under a farmer group management system was set up on a farmer's fields in Mukuyuni in Makueni County during the 2010/2011 cropping season. Three elite KARI Katumani bred sweet potato varieties, KSP20, KSP47, and SPK004 were subjected to the recommended farmers' cultural practices and farmer and researcher participatory evaluations. The data collected was subjected to analysis of variance and the treatments means were separated using the Least Significant Difference. KSP47 had significantly higher leaf retention (2.0) than KSP20 and SPK004 at the Farmer Group managed farm. On the other hand, KSP20 had significantly higher stay-green ability than KSP47 and SPK004. KSP47 was the least (2.0) infested by the sweet potato weevil while SPK004 was the most (4.3) infested. The Farmer Group managed farm had the highest harvest index (HI) (0.64) while the other three farms HI ranged between 0.25 and 0.35 depending on variety. KSP20 and SPK004 had the highest HI, 0.69 and 0.72 respectively. Harvest index for KSP47 was the most stable across the different farms, ranging between 0.31 and 0.58, meaning that some varieties are more stable than others while others are affected by management systems and availability of water. KSP20 had a significantly higher number of unmarketable roots (0.7) than SPK004 (0.2), whereas the number of marketable roots did not differ significantly among the three varieties. It seems that the number of marketable roots is a more stable parameter than the number of unmarketable roots. It also means that not all unmarketable roots develop into marketable sizes. Generally the unmarketable and marketable tuberous root yield did not differ significantly between the four farms. However, at the Farmer Group managed farm, SPK004 had a significantly higher marketable tuberous root yield (10.2 t/ha) than KSP20 (8.0 t/ha) and KSP47 (1.9 t/ha). A similar trend was observed regarding the unmarketable and marketable tuberous root yield with SPK004 having a significantly higher unmarketable tuberous root yield (4.05 t/ha) than KSP20 (0.22 t/ha) and KSP47 (1.49 t/ha). At the Farmer Group managed farm, SPK004 had a significantly higher total tuberous root yield (14.2 t/ha) than KSP20 (8.2 t/ha) and KSP47 (3.3 t/ha). At the Farmer Group managed farm, SPK004 had significantly higher top yield (6.5 t/ha) and biomass (20.7 t/ha) than KSP20 and KSP47 suggesting that pro-vitamin A rich SPK004 should be multiplied and distributed in this malnutrition-prone area.

***Development of water saving and drought resistant rice and culture practice for growing WDR by means of drip irrigation***

Zaochang Liu, Shanghai Academy of Agricultural Sciences, China

Global agriculture in this century faces two major challenges. Total food production must be increased to feed a still growing world population, and this increase must be accomplished under increasing scarcity of irrigation water resources. However, freshwater resources are increasingly becoming scarce due to increased competition among a multitude of users from all economic activities. A field demonstration trial comparing the growth status, yield ability and water use efficiency of drought-tolerant rice varieties and normal paddy rice variety under drip irrigation and paddy irrigation was carried out for three years. Under drip irrigation, both inbred and hybrid water saving and drought resistant rice (WDR) varieties showed much better yield capacity than the paddy rice varieties tested. WDR varieties under drip irrigation reached more than 95% of the yield level than that achieved in paddy field, while the paddy varieties under the same drip condition reached only about 75%. The methane gas emission was obviously decreased under drip irrigation conditions, while the emission of other greenhouse gases such as nitrous oxide or carbon dioxide did not demonstrate a significant difference between drip and paddy irrigation. It can be concluded that it is feasible to grow water-saving and drought-tolerant rice through drip irrigation. Drip irrigation maintained a competitive grain yield and water consumption, and greatly reduced pollution risk to the environment. Considering the conservative amount of fertilizer application - less than the amount of fertilization in a normal paddy field, the yield potential of rice could be improved to a higher level by increasing the amount of fertilizer as a top application in a drip irrigation system.

### ***LC-MS analysis of cucurbitacins in Namib endemic fruit -Nara (Acanthosicyos horridus)***

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The Nara is a keystone species that occurs in scattered localities across the Namib Desert. Their large but localised populations are found in dunes, dry river beds and along river banks on sand hummocks. The plants occurring in the Lower Kuiseb Valley are the most abundant and are exploited as food, medicinal and economic sources by the marginalised local !Aonin community living along the Kuiseb river bank. In contrast, plants occurring further north are less abundant, more remote, and mostly render their ecological services to local organisms. It has been hypothesised that the plants found along the Lower Kuiseb Valley may already have been preselected by local harvesters for traits of agricultural importance, and should thus be prioritised for ex situ conservation and crop development. However, despite several multidisciplinary research projects on the biological and physiological nature of the plant, previous attempts to cultivate the plant have proved futile. In addition, there are knowledge gaps regarding the genetic diversity of the plant at a molecular level and the chemical characterisation of its important secondary metabolites.

As a member of the Cucurbitaceae family, !nara contain cucurbitacins—a diverse group of tetracyclic triterpenes that are well known for their cytotoxicity, antifeedant properties and bitterness. This class of compounds has been established to have chemotaxonomic significance allowing for differentiation between plant species in cucurbitacin containing genera. In this study, the diversity of cucurbitacins in dried !nara fruit flesh from the !Nara valley in the Central Namib and Hartmann Valley in the Northern Namib were investigated using liquid chromatography coupled to mass spectrometry (LC-MS). Cucurbitacins were analysed by reversed phase LC separation followed by positive electrospray ionisation and high resolution MS and tandem MS detection. LC-MS allowed elucidation of different cucurbitacin profiles between several spatial populations. In combination with ecogeographic information and germplasm collection, LC-MS analysis shows promise as an effective tool to further unravel genetic variation of this ecologically and agriculturally important Namib endemic species.

## **On-site Waste Collection**

### ***Assessment of pathogenic bacteria in greywater systems and irrigated soils***

**Maya Benami**, Amit Gross, and Osnat Gillor; Zuckerman Institute for Water Research, The Jacob Blaustein Institutes for Desert Research, Ben Gurion University of the Negev, Sede Boqer Campus, 84990.

Reuse of greywater (GW) for irrigation is recognized as a sustainable solution for water conservation. One major impediment to the reuse of GW is the possible presence of pathogens. Sustainable, on-site GW application requires that systems be efficient, cost effective, and safe in terms of public health and the environment. To understand possible GW health risks the presence and abundance of six pathogens and indicators were investigated in three recirculating vertical flow constructed wetlands (RVFCW) treating GW. Our objectives were to: 1) examine pathogen loads in biologically treated versus disinfected GW and to 2) test for the pathogens in the soil irrigated by GW. This study was conducted in a unique field setup of three on-site GW treatment systems i.e., RVFCW's equipped with chlorinators (with time-dissolving chlorine tablets) and low pressure 50W UV lamp disinfection systems. We tested the same GW in sequence of raw, treated and disinfected GW for pathogens and indicators. In addition, we tested the GW irrigated soil in household yards and as a control sampled four soils irrigated with freshwater. The different matrices were sampled for *Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella enterica*, *Pseudomonas aeruginosa*,



*Enterococcus faecalis*, and *Shigella* spp. over the course of one year using culture –dependent and independent methods.

Similar bacterial pathogens and indicators were found in treated GW and the respective irrigated soils. Interestingly, a similar array of pathogens was also found when freshwater was used to irrigate the soil, although none were found in the water. Moreover, the abundance of these bacteria in treated GW- and freshwater- irrigated soils was of the same order of magnitude, putting to question the source of the pathogens. To further eliminate the putative health hazard posed by treated GW we tested the efficiency of simple UV and chlorine applications on the treated GW. Pathogen and indicator concentrations were markedly reduced in both methods.

Our results suggest that GW irrigation has no effect on the diversity and abundance of the tested pathogens and indicators in yard soils. We further show that disinfection is effective in treating the pathogens present in GW to lower-than-infectious dosage levels. We therefore postulate that it is possible to use GW for yard irrigation: (a) because it is possible to treat GW using low-tech systems and disinfection for safe reuse and (b) because treated GW may not be a major contributor to pathogens in yard soils.

### ***Quantitative assessment of microbial risks associated with greywater***

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Greywater reuse is quickly gaining popularity as a viable source of reclaimed water, especially in water-scarce regions. It can be used to irrigate a garden or flush the toilet. While the benefits of greywater reuse are promising, the risks are still debated. The purpose of this study was to determine, by use of a quantitative microbial risk assessment (QMRA) and a parallel epidemiological study, the health risks associated with greywater which has undergone various levels of treatment (resulting in different levels of pathogens in the water before use). For the QMRA, commonly used indicator and reference opportunistic pathogen, *E. coli* and *Staphylococcus aureus* were evaluated due to their prevalence in greywater. Five specific exposure scenarios were investigated along with determining the maximum exposure allowances. The five exposure scenarios included one-time accidental ingestion of a large amount of greywater, repeated exposure to aerosols from garden irrigation, repeated exposure from crops irrigated by greywater, repeated hand-to-mouth exposure from touching surfaces or soil in a garden which have been irrigated with greywater and one-time exposure from washing hands in the greywater. The model was run using 10,000 iterations of a Monte Carlo simulation and the results were then compared to the maximum “safe” limit of 10<sup>-6</sup> disability adjusted life years (DALYs) set by the World Health Organization (WHO). Based on the model’s results, safe use is met in all instances if *E. coli* and *S. aureus* concentration is kept below 100 CFU/100 mL and 106 CFU/100 mL, respectively. Based on reported concentrations of these bacteria in GW, these findings imply that disinfection before use is recommended. Additional means to minimize human exposure with greywater such as subsurface irrigation or fencing the irrigated area and greywater storage system would reduce the potential risk. Safe, onsite reuse of greywater can be practiced if correctly handled. The epidemiological study comprised a weekly health questionnaire answered by a group of greywater users and non greywater users (control group) over a period of one year. The results of the epidemiological study will be compared with the results of the QMRA to ascertain the validity of the model which is known to be highly conservative.

### ***Greywater reuse: Challenges and opportunities***

Eran Friedler, Faculty of Civil and Environmental Engineering, Technion; eranf@tx.technion.ac.il

Population growth, urbanization and climate change result in ever-increasing pressure on existing “conventional” water resources all over the globe. It is predicted that in 2025 40% of the world population will live under water stress conditions and 50% will live in urban areas. One of the possible ways to alleviate the everlasting pressure on existing water resources is to develop alternative ones, such as rainwater harvesting, stormwater harvesting and greywater reuse. Decentralised greywater treatment and reuse can reduce domestic water consumption by 30-40%, and thus

alleviate some of the stress on water resources. Furthermore, greywater reuse can contribute to a more sustainable use of water within urban areas. Greywater as an alternative source is especially important in arid and semi-arid regions, where it can sustain non-potable uses that otherwise would not be possible. Indeed, in recent years, greywater reuse has gained attention from both the scientific and practitioners' communities. It is estimated that there are tens or hundreds of million units worldwide. However, as greywater contains various pollutants, it may pose a potential threat to public health and the environment. Thus, reuse of greywater should be carried out only after proper treatment. In the talk, the water saving potential for different options of greywater reuse will be assessed; the status of greywater reuse in various countries will be addressed; motivations, impediments and potential hazards will be discussed; and at the end of the talk, some case studies will be described.

***Securing water supply in Israel: An eco-innovative water treatment solution applied to the desalination brine effluent***

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Israel is located in an arid region with diversified water availability patterns across the country. In many cases water consumption exceeds availability, leading to water deficits and increased competition between different water users. In order to address these challenges, Israel has turned into wastewater treatment for the agricultural sector (around 40% of the total needs of agriculture are covered by tertiary treatment) and to desalination sector for drinking water purposes. Israel is relying heavily today on desalination and according to the national water policy, desalination will be increasingly considered and used the following years (Cuenca, 2012; Fixler 2011). Even though, desalination comprises today a well established water supply practice, it is not without economical and environmental implications.

***The condensing greenhouse - a holistic, sustainable approach to small-scale water desalination in remote regions - using solar, wind and wave energy***

**Mario Schmack**, Murdoch University, Australia; M.Schmack@murdoch.edu.au

This research was motivated by the growing need for sustainable water supply technologies in arid lands worldwide. The paper explores the potential for an innovative concept that combines the well-established seawater greenhouse with a novel humidification process, the non-boiling bubble column evaporator. Optimal utilisation of solar thermal, wind and wave energy as the principal process drivers provide the backbone for this new technology. It is based on assumptions drawn from previous work by this author that investigated the performance of a bubble column evaporator in conjunction with several specially designed condenser types. A large-scale bubble column greenhouse could be combined with a WAIV brine evaporation unit. As a result, the process would produce near zero liquid discharge and thus not depend on large evaporation ponds for brine management that represent a significant cost factor. The system would produce distilled water while providing a vital humid environment that greatly reduces water demand for crop growth inside a greenhouse. As the technology is conceptually simple to implement, it also represents great potential for community participation, empowerment, skill development and capacity building of local people in remote locations. A detailed cost analysis of the anticipated system is provided. Insights from this paper will inform future research and provide a conceptual building block for an innovative water system in the future with a focus on ecologically, socially and economically sustainable fresh water production.

### ***Solar driven removal of contaminants from brackish waters using capacitive deionisation technologies***

**David Waite** and Peter Kovalsky, School of Civil and Environmental Engineering, The University of New South Wales; d.waite@unsw.edu.au

Removal of salt and other contaminants from brackish groundwaters is a priority in Australia, where there are many locations with no alternate water supplies. Reverse osmosis, in most cases, is not viable both because of capital and operational and maintenance costs. One option is that of capacitive deionisation, an electrochemical method of ion removal which, for waters that are not too salty, may be a viable alternative. The cost effectiveness of this technology is improved if i) the unit is powered by solar energy and ii) energy generated during the charging process can be captured and reused. Additionally, while non-Faradaic aspects of ion removal are reasonably well understood, much less is known about chemical processes involving electron transfer at the electrodes, so-called Faradaic processes. These processes can lead to significant pH excursions in the treated waters and result in troublesome scale formation as well as electrode oxidation and decay. Incorporation of ion exchange membranes at the surface of the electrodes – a process known as membrane capacitive deionization (mCEDI) - can reduce the severity of some of these problems and lead to improved ion removal but can result in other problems. Possible applications of this technology for treatment of brackish waters for both agricultural and domestic purposes will be discussed.

## **Poster Session**

### ***DIDAS - A user-friendly software package for assisting Drip Irrigation Design and Scheduling***

**Gregory Communar**, Alon Gamliel and Shmulik P. Friedman; Department of Environmental Physics and Irrigation, Institute of Soil, Water and Environmental Sciences, Agricultural Research Organization, the Volcani Center, Bet Dagan 50250, Israel; vwsfried@agri.gov.il

The DIDAS software package was developed for the purpose of assisting irrigators in the design of drip irrigation systems and in irrigation scheduling. The program performs computations based on analytical solutions of the relevant linearized water flow and uptake problems. Water flow is described by superposition of solutions for positive sources (on-surface or subsurface emitters) and negative sinks (plant root systems). Steady water flow is assumed in the design module and unsteady flow is used in the irrigation scheduling module. The design tool is based on a new, relative water uptake rate (RWUR, ratio between water uptake rate and irrigation rate) criterion suggested for deciding upon the distances between emitters along drip lines and between drip lines. The maximum possible RWUR is evaluated assuming no plant-atmosphere resistance to water uptake. Namely, the plant roots apply maximum possible suction and the water uptake is determined just by the capability of the soil to conduct water from the emitters to the rooting zones. The computations of the RWUR requires only a minimum number of three parameters describing the soil texture, the size of the root zone and the potential evaporation, in the few cases when it is important to account for also evaporation from the soil surface. The irrigation scheduling optimizing tool is based on a relative water uptake volume (RWUV, ratio between daily water uptake volume and daily irrigation volume) criterion. The computations of the diurnal patterns of the water uptake rates and the daily RWUV for a given irrigation scenario require additional information on the diurnal pattern of the plant resistance to water uptake and on the hydraulic conductivity of the soil. DIDAS includes also a module of quasi-steady flow for evaluating the diurnal water uptake patterns that accounts for the diurnal plant resistance and evaporation patterns and serves for fine-tuning of the design and preliminary evaluation of scheduling scenarios. DIDAS is programmed in DELPHI and runs on any Windows operating system-PC, with no further software requirements. The construction of the drip irrigation scenario is performed via few GUI windows, which contain also a library of the required input parameters, and several best-fitting procedures. The computed RWURs and RWUVs are displayed graphically and the tabulated output results can be exported to e.g. Windows Excel for further processing. A second version of the DIDAS freeware package can be downloaded from <http://app.agri.gov.il/didas>.

### ***Long-term effects of woodland planting in drylands on soil fertility and native vegetation productivity***

**David Helman**\*<sup>1</sup>, Amir Mussery<sup>o1,2</sup>, Itamar M. Lensky<sup>1</sup>, Stefan Leu<sup>3</sup>

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We evaluated the effects of *Acacia victoriae* islets planted in 1993 at the Northern Negev drylands on soil fertility and productivity of the native herbaceous vegetation. Biomass, mineral-P, N and K in topsoil, and soil organic matter, were measured from the planted and an adjacent unplanted area. The satellite-derived Normalized Difference Vegetation Index (NDVI) from MODIS was used to expand the timespan of the analysis after calibration with field data. Results showed an average improvement in biomass of 40% compared to the unplanted area. Improvement was also observed in all soils' nutrients concentrations and organic matter. Biomass was highly related to precipitation ( $R^2 = 0.90$ ,  $p < 0.001$ ), gradually declining from 2001 to 2009. Yet, the rehabilitated planted area maintained a positive effect of the woodland islets on the native herbaceous vegetation. Rain use efficiency (RUE) was constantly higher in the planted area with respect to the unplanted lands even in the driest years ( $41 \pm 19\%$ ). This is contradictory to a previous study that suggested a convergence of all biomes towards a single low RUE value under water stress conditions. The total biomass gained since plantation was estimated at  $60 \text{ g m}^{-2} \text{ yr}^{-1}$  (i.e.  $12 \text{ t ha}^{-1}$ ) for a 20-year period. Our results suggest that planting woodland islets may significantly improve soil quality and biomass productivity of the native vegetation in drylands in a relatively short time.

### ***Spectral identification of biological soil crusts in the Northern Negev***

**Ittai Herrmann**, Offer Rozenstein, Natalya Panov, Alexander Goldberg, Arnon Karnieli and Eli Zaady

Biological soil crusts (BSCs) are important components of arid and semiarid ecosystems. Monitoring BSCs spatial distribution is needed in order to better understand these ecosystems. The yearly phenological cycle of photosynthetic activity in the northern Negev can be divided to three stages: BSCs; annuals; and perennials. These elements are greening one after the other with some overlapping. The aim of the current study is to spectrally identify the greening of BSCs before covered by vegetation. Three treatments were applied: removing vegetation; removing BSCs; and control. Multispectral satellite images (Kompsat3) as well as hyperspectral ground level measurements (400-1000nm) were obtained in the northern Negev. The dates of spectral measurements were from dry season to dry season while obtaining data closely after the first rainfall event of the winter of 2013-2014. Spectral data of the two spectral resolutions were analyzed by partial least squares discriminant analysis (PLSDA) in order to explore difference between the treatments. The normalized difference vegetation index (NDVI) was calculated to assess phenology. The average total accuracy of classification for ground data sampled to satellite bands was 80% and for the images it was 76%. The average of NDVI values per treatment and date allows BSCs identification right after the first rainfall event as well as the annuals peak. Therefore, it can be concluded that: greening of BSCs can be identified based on the first significant rainfall event of the season [ $>5\text{mm}$ ]; and classification of greening BSCs and bare soil as well as covered by dry vegetation is possible.

### ***The role of dew in desert plants***

**Amber Hill**<sup>1</sup>, Oren Shelef<sup>1</sup>, Todd Dawson<sup>2</sup> and Shimon Rachmilevitch<sup>1</sup>

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Dew is often attributed as a major source of water in the desert. In arid environments, the importance of dew lies in its reliability and availability as a stable source of water throughout the year, compared with sporadic rainfall events.

There is however, an ongoing debate about the importance of dew in ecosystems in general, and especially in plants as a water source.

Dew can potentially affect the water balance at the interface of the soil - plant - environment continuum and contribute to the overall performance of the plant. The dew in plants is especially important in water limited environments, such as the Negev in Israel. The Negev is an arid ecosystem, which receives rain only during the winter (October to March), similar to the northern part of the Sahara Desert. In contrast to rainfall, there are measured on average 200 dew days a year that account for over 30% of the annual precipitation in this region. However, the contribution of dew in plants still remains a mystery.

We seek to determine the fraction of dew absorbed directly by three different plant species in the desert, and the importance of this coverage to the development and survival of plants in the desert.

We examined three different species of desert plants that grow naturally in the Negev, both in their natural habitat and in laboratory conditions. Two perennials: desert sage - *Artemisia sieberi* Besser (Asteraceae) whose roots are relatively short (30 cm), and *Haloxylon scoparium* Pomel (Chenopodiaceae) which has a root system that is relatively deep (100 cm). The third species is an annual, - *Salsola inermis* Forssk (Chenopodiaceae) with 15-30 cm deep roots. Understanding the mechanisms of plant water use and adaptation to stress are necessary to preserve the plant productivity and efficiency as well as sustainable use of water globally.

### ***Relating landscape ecohydrology to vegetation patchiness in a long-term field experiment***

**Oren Hoffman**, Ben Gurion University of the Negev, Israel

The connection between landscape structure and function is a pivotal theme in the field of ecohydrology. This is especially prominent in the study of drylands, where resources, especially water and nutrients, tend to be redistributed and concentrated in sink patches. In this context, the identification of structural metrics that can be quantitatively related to landscape functionality has been in the focus of research for ecologists and land managers.

We use data from a long-term experimental system of landscape disturbance and runoff collection to assess the correlation between metrics derived from low altitude photography and runoff generation, which is a measure of landscape leakiness.

By creating thematic binary maps from RGB photos, we calculated cover and connectivity  $C$  of bare-ground patches at increasing lag distances  $h$ . Using the decay function of connectivity  $C(h)$  we identified the “connectivity range”  $\alpha$  for each plot. Linear models were used to evaluate the relation between  $C$  and  $\alpha$  to runoff at the time-scales of a single event and a whole season.

Throughout the last two decades, changes in cover of annuals and shrubs have taken place due to succession following the treatments, and to changes in long-term precipitation patterns (an increase in drought frequency). We estimated these changes, and related them to changes in landscape functionality and recovery trajectories.

The treatments caused a divergence in vegetation patterns, with  $C$  and  $\alpha$  both differing drastically between the herbicide application and the mowing treatments, but were highly varied for control plots. The measured connectivity metrics were able to explain a large part of the variability in seasonal runoff amounts, irrespective of treatment, whereas for single events their explanatory power was weaker.

Throughout two decades, the cover of annuals increased in all plots, while cover of shrubs decreased due to adult shrub mortality. Mowing produced decoupling of shrub and annual cover, which was later evident in the other treatments due to lack of grazing and shrub die-off.

Simultaneous changes in woody and herbaceous cover, and specifically coupling and de-coupling processes between the cover types, are phenomena caused by response to environmental drivers, and are key factors to changes in landscape functionality.

### ***Growing safflower (*carthamus tinctorius l.*) in the semiarid northeastern Brazil***

**Juliana Espada Lichston**, Émile Rocha de Lima, Raimunda Adlany Dias da Silva, Allyne do Nascimento Eufrásio Silva; Federal University of Rio Grande do Norte-UFRN, Department of Botany and Zoology, Research Laboratory of Energy Crops, Natal-RN, Brasil. j.lichston@gmail.com

Soil and climatic conditions of the semiarid Northeast Brazil, with high temperatures, reductions in rainfall and consequent low water availability in the soil, limiting the development of agriculture. The *Carthamus tinctorius* L., is an oilseed belonging to the *Asteraceae* family, it is an annual, herbaceous plant and characterised by its resistance to drought, high temperatures and the special soil conditions, with potential for cultivation in semiarid regions. The safflower has a large socioeconomic importance because it is used to dye foods, drinks, clothes and cosmetics, still has value in the medical and pharmaceutical industry and it is used as animal diets, and its seeds have potential in the biofuel industry. Thus, the objective of this study was to analyse the germination and anatomy of the vegetative organs of *Carthamus tinctorius* L. growing in semiarid region of Rio Grande do Norte. The safflower was grown in the field under drought conditions and with weekly irrigations. For anatomical analysis, semi-permanent histological microscope slides of stem and leaf were prepared, stained with 1% Alcian blue and Safranin 1%. Germination rates of irrigated and rainfed specimens were 91% and 1% respectively. Anatomically, showed the presence of parenchyma, sclerenchyma close to the vascular bundles, thick cuticle and mucilage ducts in the stem. In leaves, there was a significant amount of mucilage ducts near the ribs and scattered throughout the mesophyll, which is symmetrical with several layers of palisade parenchyma, and epidermis with thick cuticle and trichomes. The thick cuticle, acceleration of growth and life cycle, according to the literature, and mucilage ducts are characteristic of plants of arid environments. Therefore, it is concluded that *Carthamus tinctorius* L. presents great development and survival adaptations that allow the culture of this specie in the semiarid of northeastern Brazil bringing positive impacts to the region's agriculture.

### ***Semiarid northeastern Brazil: general aspects***

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The Brazilian semiarid region covers about 980 km<sup>2</sup>, comprises nine states in the Northeast and Southeast regions of Brazil: Alagoas, Bahia, Ceará, Minas Gerais, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe. In this region, living 22 million people, representing 11.8% of the population, according to the Brazilian Institute of Geography and Statistics (IBGE). It is the most populous semiarid region of the planet. The semiarid region has most of its territory covered by the biome Caatinga, only exclusively Brazilian biome that is rich in endemic species. The floristic composition of the Caatinga is not uniform throughout its length. Presents a variety of landscapes, animals and plants, native and adapted species with high potential and ensure the survival of farming families in the region. Another feature of the Brazilian semiarid region's water deficit. However, this region is characterized as the wettest semiarid of the planet. The average rainfall from 200 mm to 800 mm annually. However, the rains are irregular in time and space. Furthermore, the amount of rain is less than the rate of evaporation which is 3000 mm / year the evaporation is three times greater than the rain that falls. In addition, the Brazilian semiarid region is marked by a historic structure concentrates wealth, riches, land and water. The economy is primarily extensive livestock farming and low-income family that goes on a severe slope in dry periods, even causing failure of crops and animals. Since 2011, the semiarid region has suffered a major drought ever faced in thirty years. Half of the 504 reservoirs monitored by the National Agency of Waters (ANA) is below capacity. In 2013, the National Secretariat of Civil Defense acknowledged that 1484 northeastern and northern Minas Gerais municipalities were in emergency because of drought, affecting 10.67 million people.

### ***Shrub cover as a stimulus of arthropods community in desertified regions***

**Rentao Liu**, Key Laboratory for Restoration and Reconstruction of Degraded Ecosystem in Northwestern China of Ministry of Education, Ningxia University, Yinchuan 750021, China; Yosef Steinberger, The Mina & Everard Goodman Faculty of Life Sciences, Bar-Ilan University, Ramat-Gan 5290002, Israel; nxuliu2012@126.com (R T Liu).

In desertified regions, the shrub patch distribution plays a crucial role in structuring the arthropods community composition, density, and diversity. The aim of the present study was to elucidate the spatial distribution of shrub patch on above- and below-ground arthropods community in a desertified grassland ecosystem, northwestern China. A shrub cover desertified region was selected such as the shrub age and the distance between them for the arthropod activity and density determination. The arthropod activity was monitored (1) at two levels, e.g., above ground and below ground at two layers from 0 to 10 and 10 to 20 cm soil layers, and (2) under *Caragana koushinskii* revegetated shrubs of 6, 15, 24 and 36 year-old plantations. In addition a control sampling site in the interspaces between the shrubs was used. All the arthropods samples obtained during the sampling period were taxonomically and their trophic groups determined. The above-ground arthropods collected in the microsites beneath, near and between shrubs during spring, summer and autumn seasons, had showed a strong seasonal effect, elucidating a shrub patch effect on arthropod community. Total abundance, group richness and the Shannon's index (except the total abundance in autumn) indicated significantly higher values in the microsites beneath shrub canopy in comparison to the control interspace sampling sites. Group richness was significantly higher in the microsites near than far from shrub canopy. However, the results did not showed any overall positive relationship between shrub age and arthropod abundance, richness or diversity index. The influence of plantation age on arthropod communities was found to be affected by seasonal changes. The recovery of arthropod communities by revegetated shrubs was markedly affected by seasonal variability, and they demonstrated distinctive communal fingerprints in different microhabitats for each plantation age stage. The present study elucidate the importance of plant cover that perform 'keystone structures' functions, providing heterogeneous microhabitats that alters in time and space increasing micro-niche opportunities to arthropods community allowing them to fulfill their biological role in xeric environments.

### ***Feedback mechanisms to model gap patterns – Fairy circles in Namibian drylands***

**Theresa Moeller-Lindenholz<sup>1</sup>** and **Stephan Getzin<sup>2</sup>**

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Dryland ecosystems with strong plant competition for resources such as water reveal regular vegetation pattern formation resulting from self-organization. In order to understand the underlying mechanisms of pattern formation, partial-differential equations are used to model the vegetation patterns mathematically. The equations include several positive and negative feedback mechanisms playing a crucial role in the pattern formation processes. The poster summarizes the different feedback mechanisms, which have been taken into account so far. The feedbacks comprise local and non-local interactions between plant biomass and water, which is the limiting factor in dryland ecosystems. Leading to a redistribution of soil-water resources reflecting the spatial distribution of biomass, the feedbacks embody the self-organization of plants to withstand harsh environmental conditions. The patterns produced by partial-differential equation models range from spot patterns to labyrinths to gap patterns on an increasing precipitation gradient. So-called fairy circles found in Namibia represent a gap pattern in real ecosystems. Its formation is controversial and vividly discussed in the current scientific debate. However scientists were able to model fairy circles in accordance with their real spatial arrangement by implementing the most relevant and realistic feedback mechanisms. Despite of this finding many questions about fairy circles remain unanswered, such as the mechanism causing their temporal dynamics or the underlying processes altering their spatial distribution under more heterogeneous habitat conditions.

### ***Natural Biological Systems for sustainable decentralized water treatment: principles and case studies***

**Ezra Orlofsky**, Ayala Water and Ecology, Tsipori, Israel

The high energy and maintenance costs of conventional sewage treatment systems (up to 35% of total energy demand in some cases!) are becoming an unbearable component in developing countries as well as developed ones. Centralized wastewater treatment technologies are particularly hard to implement especially in underdeveloped regions. Natural Biological Systems (NBS) is a hybrid phytoremediation based technology developed by Ayala Water

& Ecology for decentralized and electricity independent wastewater treatment systems that can be scaled to meet any need (watershed to single residence). Case studies illustrating the effectiveness of NBS, including river rehabilitation, dairy farms, gas stations, landfill, and industrial plants show that organic pollutants and pathogens are significantly removed (>90% removal, up to 7- log removal, respectively), metals and minerals are removed from 30-90%, while targeted removal of other pollutants, including nitrogen, needs to be accompanied by specific design elements in order to be effective. Given the appropriate policy framework, decentralized, low-energy systems could relieve tremendous economic and environmental burdens associated with wastewater treatment.

***Thermal ecology and locomotor performance of the critically endangered stout iguana (Cyclura pinguis)***

**Gad Perry**, Texas Tech University, USA

Body temperature ( $T_b$ ) is one of the most important ecophysiological factors influencing performance, behavior, and fitness of ectotherms. Consequently, there has been considerable research interest in reptilian thermal ecology and the temperature sensitivity of performance capacities. Herein we describe the results of a thermal ecophysiology study on an artificially established insurance population of stout iguanas (*Cyclura pinguis*) translocated from Anegada to Guana Island, British Virgin Islands. As a result of vegetative and topographic differences between islands, there are dissimilarities in their thermal environments. Therefore, our objectives were to determine the preferred and field active body temperatures of the Guana hatchling population and to assess the influence of body temperature on both sprint performance and endurance. Additionally, we sought to compare our results to published thermal data from the Anegada population and to evaluate the differences in thermal sensitivity and locomotor performance between head-started and wild hatchlings on the two islands. Field active  $T_b$  of Guana hatchlings ranged from 27.6 to 43.0°C with an average of  $36.8 \pm 0.2^\circ\text{C}$ , and laboratory tests of preferred temperature showed an average of  $39.5 \pm 0.2^\circ\text{C}$ . Both field active and preferred temperatures were similar to thermal values published for the Anegada population. Preliminary results indicate that sprint and endurance performance both show thermal sensitivity, with maximum performance occurring between 38 and 39 °C. Head-started animals had slightly lower endurance times than wild hatchlings. These data provide valuable information on the thermal ecology and performance of two populations of a critically endangered species.

***Emergence, growth, and survival of seedlings in a mobile sandy desert with phytogenic mounds: a spatiotemporal study of the effects of ecological drivers***

**Jan Quets**, Magdy I. El-Bana; Saud L. Rowaily; Abdulaziz M. Assaeed; Stijn Temmerman; Ivan Nijs;  
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Phytogenic mounds (i.e. vegetated dunes called nebkhas) are widespread in drylands where they often are buffers against the damaging effects of land degradation and desertification. Recruitment vulnerability in nebkha landscapes is however understudied, while desertification is globally intensifying. We therefore attempted to unravel whether and how emergence, growth, and survival of *Rhazya stricta* Decne. nebkha recruits are spatially affected by biotic and abiotic ecological drivers. Hereto, we performed Monte Carlo-based spatiotemporal analyses on four self-made remotely sensed maps (including elevation data) acquired over a three-year period from a study site within central Saudi Arabia. The results indicated improved emergence of recruits in topographic depressions (interpreted as the result of better soil moisture conditions and seed concentration) and around adults (interpreted as the result of increased seed arrival). Seedling growth was unexpectedly faster in poorly vegetated regions, probably because of geomorphologic induced increased sand burial, but was severely suppressed near adult vegetation by means of competition. Seedling survival was overall high, but further improved nearby nebkhas, most likely as a result of increased resource levels and cooling by nebkha shadows. As seed limitation for *R. stricta* is known omnipresent. These findings suggest that correctly timed seed addition in depressions, and an optimized distance between planted cuttings might improve the efficiency of man-made encroachment of nebkhas as a potential mitigation measure against desertification.



### ***Preliminary screen of 30 new introduction cultivars of *Ziziphus jujuba****

**Buzi Raviv**; Ben Gurion University of the Negev; Israel

*Ziziphus jujuba* (Mill.), also known as Chinese date or Jujube, is a deciduous tree species originating from China that can cope with extreme temperatures, drought and salinity. *Z. jujuba* is known as an exotic fruit crop and also as a good source for medicinal uses which make it a promising candidate crop for the Negev region. *Ziziphus jujuba* trees bloom with intensity but the levels of fruit set are relatively very low. Planting complementary anthesis type trees in the orchard is assumed to increase yields. In this work, several agricultural traits were monitored during two growth seasons in order to choose candidates for local breeding program.

Variation in pollen viability and size, fruit shape and size, tree architecture, maturation of the flower organs, length of the blooming period, timing of dormancy break and timing of anthesis were detected for the introduction cultivars. Two male sterile cultivars were detected. DNA content and stomata density measurements – suggest aneuploidy in cultivar “GA 866”.

In conclusion, the collected data may help to develop a matrix for cultivar combinations in the orchard to improve yields and choose specific cultivars for breeding programs and further research.

### ***Environmental conditions of urban spaces in a desert town: the case of Mitzpe-Ramon, Israel***

**Fabio Scheinkman**, “Bona Terra” Department of Man in the Desert, J. Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev; Dead Sea & Arava Science Center, Ramon Branch; fabio.g.sch@gmail.com

This research shows the ways that different planning fashions affect the micro-climate conditions in Mitzpe-Ramon, a town of approximately 5,000 residents located in the Negev highlands. Albeit relatively small, the town’s cityscape is versatile: Different features can be found along the neighborhoods, and even in different spaces within a single neighborhood.

Ambient temperatures and wind velocity were measured during regional peak summer month of July on diurnal cycles. In addition, in order to understand the relation between materials and shading to micro-climate, infrared photos of each site were taken with an infrared camera. Data were collected from ten sites with different planning fashion and spatial characteristics.

Surprisingly, most convenient environmental conditions measured were those in wide open 'urban desert' space, despite its scarce vegetation and almost total absence of shadow. Regarding residential neighborhood, the most convenient environmental conditions measured were those in 2-3 stories buildings built in the 1950's cluster known as the old neighborhood. The worst environmental conditions measured were those in dense semi-detached cluster in "Ein-Ofarim", a prefabricated neighborhood built in the 1970's.

Analyzing differing physical characteristics of the sites measured, this research explains the causes for these micro-climate discrepancies. Promoting urban planning which is conscious of environmental constrains consists of various variables, some of which are discussed in this work. Preliminary results and hypotheses can be derived from this research for further research ahead, and can be presented to planners, local decision makers and residents in order to promote a more of an environmental conscious urban fabric.

### ***Land-use change, a case study from southern Italy: General implications for agricultural-subsidy policies***

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Culture, legacy and ecosystem services in southern Italy is deeply connected to agricultural activity. Deep changes in the last decades are emphasizing the role of local governance in maintaining these values. This impression is clearly

realized looking at two agricultural processes and regulations: land degradation and old olive orchard conservation in Puglia region.

For many years, farmers across Italy have struggled to prepare rocky landforms for farmlands. Recently, heavy machineries are widely used. Nearly 40% of Puglia lands in southern Italy have been converted to farmland through these methods. In the short term, rock grinding enriches the soil with nutrients, but over the long run soil erosion and land degradation become prominent.

Old olive trees have important aesthetic, ecologic, historic and other values that justify conservation efforts. However, farmers are seeking financial justification for growing old trees with low yield. Local organization provide guidance and support to allow additional benefits from agro-tourism and labeling organic old tree olive oil. This support restores the agriculture landscape.

These Italian case studies should be considered as an alarming example of the possible detrimental effects of national policies supporting the conversion of natural landforms into agricultural lands, alongside with the promise of local governance that brings comprehensive economic benefits rather than short-term ones.

### ***Land degradation and ecosystem function loss***

**Nora Steurer**, Michel Bakkenes, Arno Bouwman, Ben ten Brink, Stefan van der Esch, Kees Klein Goldewijk, Jan Janse, Machteld Schoolenberg; PBL Netherlands Environmental Assessment Agency

Lack of clear definitions and coherent data/maps limit understanding of scope and severity of land degradation. PBL uses ecosystem function changes to determine land degradation, including carbon storage, water availability, food/fiber production and biodiversity. In the process of ecosystems alteration some functions increase at the cost of others. Function loss happens around the world. Socioeconomically speaking, land degradation impacts some regions more than others.

The study's aim is to inform policy makers regarding extent, severity and potential consequences of land degradation, and possible benefits degradation prevention /restoration offer.

We map four components: Historically degraded areas (areas that should be more productive given climatic and biome conditions); Current/ongoing degradation (NDVI based trends over 30 years); Soil properties (SOC, NPP, soil depth, sand/clay); Functions based on soil properties: carbon storage, water availability/stress, potential agricultural area/productivity. Additionally, we undertake a systematic review regarding socioeconomic impacts of land degradation and design scenarios till 2050, including a BAU scenario, full restoration scenarios, optimized scenarios, and a hot spot scenario (socioeconomically vulnerable areas).

Biophysical: A terrestrial area of ca. 20 million km<sup>2</sup> lost more than 20% of its greenness and productivity.

Socioeconomic: Conditions limiting abilities to cope with degradation, thereby exacerbating its socioeconomic impacts include agricultural dependence, lack of functioning decentralization, remoteness, lack of adaptation possibilities/exit strategies. Regions where conditions apply are signaled as vulnerable.

Interesting are those areas with high socioeconomic impact from land degradation (hot spots), *and* with favorable multiple-function restoration conditions at the same time.

### ***A strategic environmental management plan to monitor and mitigate the effects of uranium mining in the central Namib, Namibia***

**Theo Wassenaar** and Gabi Schneider, Gobabeg Research and Training Centre, Namibia

The Strategic Environmental Assessment (SEA) for the “uranium province” – a part of the central Namib where uranium-mineralized zones are concentrated in a relatively small area – provides a mechanism for mitigation and minimization of potential impacts by mining and exploration. Driven by sustainability principles, the SEA and its associated management plan, the Strategic Environmental Management Plan or SEMP), defines an agreed vision of an acceptable environment and aims to foster a culture of collaboration within the mining industry and between government, industry and the public. At the heart of the initiative is a broad agreement among all stakeholders that the

uranium mining industry in Namibia should leave a positive legacy and should minimise harm to the environment and to society.

As the key mechanism through which the sustainability principles of the SEA are mainstreamed, the SEMP provides an over-arching framework and roadmap for addressing the cumulative impacts of a suite of existing and new developments. It defines twelve Environmental Quality Objectives (EQOs), each of which represents a commitment to an acceptable, healthy environment in terms of components such as air quality and radiation, water, tourism, biodiversity, economics, health and so on. Each EQO has a specific aim and comprises a number of so-called desired outcomes, specific targets and measurable indicators. For example, in the EQO called "Effect on tourism", which aims to prevent undue impacts on the natural beauty of the desert and its sense of place by the Uranium Rush, one of the specific targets here is that "direct and indirect visual scarring from the Uranium Rush [should be] avoided or kept within acceptable limits", and one of the indicators is that "the majority of tour operators continue to regard [specific tourist] areas ... as a 'significant' component of their tour package". Through an annual survey of tour operators, this particular indicator is thus monitored for changes over time. In total, the SEMP comprises 12 EQOs, 46 targets and 125 indicators. A Steering Committee, made up of all line ministries, civil and private organisations evaluates the monitoring results and annually publishes a SEMP Report, which is made available through websites and through all key stakeholders. With only two reports having been completed so far, it is too early to evaluate the initiative's effectiveness in achieving all its aims, but it is evident from public and industry response that there is broad acceptance of its aims and its integrity.

### ***Stochastic Desertification***

**Haim Weissmann**, Bar-Ilan University

The process of desertification is usually modeled as a first-order transition, where a change of an external parameter (e.g., precipitation) leads to a catastrophic bifurcation followed by an ecological regime shift. However, vegetation elements like shrubs and trees undergo a stochastic birth-death process with an absorbing state; such a process supports a second-order continuous transition with no hysteresis. Here we study a minimal model of a first-order transition with an absorbing state. When the external parameter varies adiabatically the transition is indeed continuous, and we present some empirical evidence that supports this scenario. The front velocity renormalizes to zero at the extinction transition, leaving a finite "quantum" region where domain walls are stable and the desertification takes place via accumulation of local extinctions. A catastrophic regime shift may occur as a dynamical hysteresis, if the pace of environmental variations is too fast. Due to this work we suggest that the most important early-warning signals are not those indicating an impending tipping point but those suggesting that large nuclei of bare soil may invade the vegetation phase.

### ***"Apparatus" Patent, Capabilities and Purposes***

**Yitzhak Zinger** – Patent inventor, Sde Yitzhak; yz47@bezeqint.net

The "Apparatus" patent is a fast soil penetration system for capturing runoff rainfall water.

There are two options to use the "Apparatus" system for capturing of the runoff water:

Tree irrigation: The purpose of this patent and its capabilities is to contribute towards building a deep root system for the tree's roots, providing large volumes of water that would otherwise have evaporated or vaporized, or would flow out to sea. The tree roots also receive significant quantities of air, which is essential for preserving soil temperatures deep in the soil. These data ensure much better chances of survival during drought years, and optimal growing conditions in severe arid conditions, when the trees growing there are adaptive to this environment.

Insertion of water to the aquifer: For water insertion, the "Apparatus" will be bigger in all its dimensions. It will be located in a sedimentation pool, connected to the seasonal stream. Part of the upper level from the stream of runoff water enters this pool, and flows through the "Apparatus", then by way of deep drilled boreholes reaches the aquifer. In this "Apparatus", a primary filtration stage prevents large and medium sized objects from entering the system. A secondary filtration stage is internal and prevents all particles, even the smallest size, from penetrating, ensuring pure water. This is achieved through its unique structure that also contains a receptacle for collecting fine material, and also

enables it to self-clean. It is capable of performing well even when submerged in flood water. The "Apparatus" is built to last for many years.

## Public Health

### *Brucellosis in the Negev: Epidemiological, social and economic perspectives*

**Nadav Davidovitch**; Ben Gurion University, Israel

Brucellosis is a zoonotic disease transferred through the intake of unpasteurized dairy products. Bedouins in Israel are the main high risk group about 65% of the cases during the last two decades were reported in the Negev region. Although Israeli public health services and the veterinary services tried to control the disease for several decades, including organizing veterinary vaccination campaigns and health promotion programs, the incidence of infection among Bedouin's sector is still very high. In my presentation the dilemma of brucellosis high incidence rate among the Bedouins will be analyzed from an Eco-health perspective; present the current efforts and suggest solutions or policies required in order to deal with an ongoing public health problem.

### *Installation of solar panels in houses of chronically ill infants and children in the Arab Bedouin villages of the Negev for the operation of medical equipment and reduction of use of diesel powered generators*

**Ilan Fathi**; AJEEC-NISPED (the Arab-Jewish Center for Equality, Empowerment and Cooperation – Negev Institute for Strategies of Peace and Development).

The Arab Bedouin community of the Negev is one of Israel's poorest, most marginalized populations. Half of the Negev Bedouin, approximately 100,000 people, live in communities that are unrecognized by the government of Israel and therefore do not receive basic services such as electricity, running water, garbage collection, paved roads, schools, clinics, and more. Children under 14 years old represent 50% of this population.

The lack of electricity in the unrecognized Bedouin villages of the Negev constitutes a major hazard for chronically ill children and premature infants as it makes it impossible to refrigerate medications or operate life-saving medical equipment. According to the Ministry of Health, infant mortality is up to six times higher in the Bedouin community than Israel's national average. Inadequate access to electricity and clean water compound this statistic. To date, AJEEC-NISPED has provided solar energy systems to 50 families to address this vital need.

By developing microfinance loans coupled with a financial incentive scheme for the reduction of greenhouse gas emissions, Bedouin families are given the opportunity to replace the polluting diesel generators with individual off-grid solar home systems. The program's aim is to improve beneficiaries' health, reduce the environmental impact of fossil fuels, and raise awareness of renewable energy.

AJEEC-NISPED works closely with doctors and social workers at the Soroka Medical Center to identify families in need of support. Once a family is chosen, a solar power system is installed in their home, ensuring that a sick child can return home with the essentials needed to help her out of the danger zone. Together with our strategic partners, AJEEC-NISPED received the 2013 National Energy Globe Award for our work in improving the lives of Bedouin children in the unrecognized villages of the Negev through solar power.

Founded in 1998, AJEEC-NISPED is an Arab-Jewish community development organization based in Beer Sheva, Israel. We work towards creating equal, inclusive, and flourishing societies. In Israel, we focus primarily on the most marginalized populations, namely the Negev region's Arab Bedouins. All programs emphasize community ownership and are holistic, empowering, and culturally competent.

***The factors influencing the sexual and reproductive health of Eritrean asylum-seeking women while en-route to and in Israel***

**Tsega Gebreyesus;** School of Public Health, Johns Hopkins University

According to the United Nations High Commissioner for Human Rights, a large proportion of migrants endure human rights violations, discrimination, and exploitation throughout their migration experiences. Those migrants making claims for asylum are particularly vulnerable to abuse due to the often irregular nature of their movement, breakdown of traditional forms of protection and support, and an inability to avail themselves of the protection of their home country. Female asylum seekers, in particular, suffer a heightened risk of sexual violence. These trends are borne out among the Eritrean asylum-seeking women who are the subject of this paper. Eritrean women asylum seekers risk the possibility of sexual violence in addition to the challenges that both Eritrean men and women asylum seekers face: the impossibility of legal emigration, a shoot-to-kill policy at the national border, the difficulty of crossing the desert or sea, enslavement and torture by human traffickers, hardship in refugee camps, and the challenges of being undocumented upon arrival at any destination. Using qualitative methodologies, this paper extends current research on the risks of sexual violence among involuntary migrants.

***Climate change and health - an Israeli perspective***

**Michael Gdalevich;** South Health District, Ministry of Health, and Faculty of Health Sciences, Ben Gurion University, Israel

Israeli preparedness for climate change is based on three main foundations:

1. Developing rapid surveillance methods for emerging and reemerging infectious diseases:
  - a. Defining high risk populations or regions
  - b. Evaluation of climate change influences on health in Israel, related to issues such as water scarcity, air pollution etc.
2. Providing information to the public, especially for high risk populations
3. Promoting integrated research with a focus on environmental epidemiology including international collaboration

There is an urgent need to create a national database that includes health outcomes. The computerized medical records of Israeli sick funds and hospitals. This infrastructure can facilitate an immediate response for the need to investigate the environmental influence on public health in real time and with great precision. Establishing such an integrated database is of utmost importance and should be part of climate change response in Israel.

***Levinsky Clinic for detecting sexually transmitted diseases and HIV- Access to health and social services for people with no legal status or asylum seekers***

**Yael Goor;** Ministry of Health, Tel Aviv Health District, Israel

Levinsky Clinic is a community clinic for sexually transmitted diseases and HIV/AIDS. The clinic belongs to the Ministry of Health and is located at the Central Bus Station in Tel Aviv. The clinic's staff is engaged in promoting "physically and mentally safe sex " and provide health education and run a mobile clinic on the street, for people with no legal status and people that are trapped in the cycle of prostitution. In early 2007, the staff of the clinic won the Social Worker Entrepreneur Award, for developing the mobile clinic and operating it without any extra budget. A year later the clinic got a dedicated budget from the Prime Minister's office within the framework of the national program to fight prostitution. In 2014, the Levinsky clinic staff won the State Medal for fighting human trafficking and for providing health and welfare services for victims of human trafficking for prostitution.

In this lecture, I will present the activities of the clinic, with a special focus on the services provided to the homeless, people with no legal status and asylum seekers. I will address the needs of this population from the viewpoint of Levinsky Clinic's staff, the activities that we developed to answer those needs and the difficulties in implementing those solutions and expanding them with reference to the lack of government policies for the treatment of this population. I will present a case study of an HIV+ stateless man from Eritrea, discussing the challenges involved

when dealing with such cases. Finally, I will present the mobile clinic experience to join non-governmental aid organization and people from the Eritrean community, through the Sexual and Gender Based Violence (SGBV) forum to raise the issue of stateless people involved in prostitution, for the benefit of those people.

### ***Diabetes Care in Palestine; between Reality and Challenges***

**Ahmad Abu Halaweh;** Augusta Victoria Hospital

Diabetes is considered the third cause of death in Palestine. In 2010, the estimated prevalence of diabetes mellitus was 14.5%. The forecasts for prevalence of diabetes in Palestine are 20.8 % for 2020 and 23.4 % for 2030.

Palestinians receive health care through five providers responsible for primary, secondary, and tertiary health care: Palestinian Ministry of Health (MoH), United Nations Relief and Works Agency (UNRWA), Palestinian Non-governmental Organizations (NGO), Palestinian Military Medical Services (PMMS) and the private sector. Ministry of Health (MoH) operates the largest number of primary health care centers in the West Bank and Gaza Strip in different levels. Diabetes care is mainly provided through the primary health care system.

In Palestine, the cost of diabetes care is high and increasing due to the fact that health care systems are not ready to deal with this disease and its complications in a proper way. The health care system is fragmented and there is no unified national protocol in place to fight the big burden of the disease. There is great need for an information system to link primary health care clinics of different providers, and hospitals together. The basic information in medical file, as well as referral notes and reports, should be shared automatically between all providers; such an action would dramatically reduce service duplication and big burden of over expensing of medications. The dual role of the MoH as a direct service provider and as a strategic planner affects its vital role as health planner and policy maker and makes MoH invest excess time and energy in service provision.

There is great need for a serious health care system reform to unify services and to ensure universal coverage of equitable health services in Palestine. Information system, health insurance, and sustainable financing systems are key components in such a reform. Strengthening the primary health care system and training front line professionals are important measures to function as gate keepers to patient referral to secondary and tertiary care.

### ***Desertification and Infant Mortality in Colombia***

**Marta Cecilia Jaramillo-Mejía;** MD. PhD Cand. University of Granada; Facultad de Ciencias Administrativas y Económicas, Universidad Icesi; Calle 18 # 122-135 Pance, oficina # 1523.  
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In spite of its proximity to the equatorial and tropics, Colombia is “mega-diverse”. It comprises a wide range of environments and ecosystems. And, according to the Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM) 24% (274.020km<sup>2</sup>) of continental lands in Colombia was susceptible to desertification in 2012. In 2007 only 17% (193.510 km<sup>2</sup>) of that land was affected by desertification. The fast land degradation processes, especially considering the water-rich context and legacy, extraordinarily affects biodiversity and hydrological cycles, food security, as well as poverty and violence.

Deteriorating water and fertile land supplies adversely affect the quantity and quality of safe water and food availability, both from agriculture and animals, in a traditional and poor population with high infant mortality rate (IMR), in the range of 25-20, to start with. In the affected areas, these changing conditions are hypothesized to contribute to a slowdown, and even reversal of Colombia’s effort to reduce its IMR. These conditions counter-act the efforts to reach out with medical services. Infant mortality especially in the post-neonatal period is hypothesized to increase because of low quality breast feeding, induced early weaning, and increased risk of infection – from higher animal deaths, polluted water, and increasing problems of managing human waste.

The study is based on about 6 million complete records of live births and deaths in Colombia, combined with data about service use and availability for the period 2001–2011. The data include mothers’ and infants’ demographic and socio-economic characteristics and care received. The study uses multivariate methods to establish the effect of desertification while accounting for the effects of socio-economic conditions and availability and use of medical services.

***Keynote: Perspectives on climate change from ecological public health***

**Colin MacDougall**; Flinders University, Australia

For scientists, policy makers and civil society groups in countries like Australia both formal and experiential evidence about climate change is persuasive. However, powerful political and economic interests deny climate change and denigrate those who seek solutions to the problem. It becomes easier for them to ply their trade of doubt sowing by highlighting how different disciplines approach climate change in different ways, and how there are debates within disciplines about how best to offer solutions. Climate change is therefore a wicked problem, with disputed causes (or even existence) and lack of consensus about what needs to be done. The health sector is large and expensive, with many commentators expressing grave fears about the capacity of governments to fund anticipated future growth in expenditure: even before the significant effects of climate change are factored in. Public health is the part of the health sector that traditionally responds to social, economic and political determinants of health, so it is a natural home for debate about climate change. However, the same power groups that oppose the science and action of climate change attack some branches of public health. Further, parts of western public health show the influence of medicine by putting people squarely at the centre of its endeavours. As public health has evolved, it has focused more and more on incorporating climate change into its models and mantras. However, more recently, an ecological approach to public health has developed, putting the interests of the planet front and centre. To be successful, ecological public health must be able to contribute to some big challenges for the health sector. These include involving children as citizens in the making who can contribute to recovery from disasters fuelled by climate change; and reconciling and synthesising scientific and Indigenous ways of knowing. The guiding principles of ecological public health are equity (social and environmental); sustainability; conviviality and global responsibility. These principles provide a language that can be common for climate change, desertification, ecological and ecological public health scientists. The presentation will set out the history and principles of ecological public health, and use case studies to show how it can contribute to climate change and desertification.

***Tuberculosis screening and disease among migrants from the horn of Africa arriving in Israel***

Zohar Mor, Ramla Department of Health, Ministry of Health, Ramla, Israel

*Objectives:* Israel received >60,000 migrant from the horn of Africa (HoA) since 2006. They were detained and screened for tuberculosis (TB) by an interview and chest X-ray (CXR). This presentation aims to demonstrate current trends of TB-morbidity, describe the screening policy and evaluate its yield.

*Methods:* National data were received from the TB-registry. Evaluation of the screening process was performed by a cross-sectional study in a random sample of the migrants arrived in Israel in 2009, and assessed its related-costs.

*Results:* The proportion of migrants from HoA of all TB-patients in Israel has increased since 2006. Most of these migrants were living in Tel-Aviv.

In a random sample of 1,087 (20.4%) of all 5,335 HoA-migrants who arrived in 2009, 62 (5.7%) had CXRs showed TB-suspicious findings, while 11 were finally diagnosed with TB. TB point-prevalence was 1,000 cases per 100,000 migrants (=1.0%). CXRs' sensitivity, specificity and positive predictive value were 100%, 96.1%, 17.7%, respectively. The interview did not contribute to detecting migrants with TB. Direct costs related to the detection of single TB-case in prison was 3,750€, lower than the treating cost (~6,000€).

During 2008-2010, 88 HoA-migrants were diagnosed with TB in the community after being screened at the prison. The average annual TB-incidence in the community was 132 cases for 100,000 migrants.

*Conclusion:* CXR-based screening is a valid and cost-saving tool for screening migrants from HoA for TB, while the interview has significant limitations. Migrants are still diagnosed with TB in the community although they were screened upon arrival.

***Climate Change Impacts on West Nile Virus***

**Shlomit Paz**; Department of Geography and Environmental Studies, University of Haifa, Israel;  
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West Nile virus (WNV) is a virus of the family Flaviviridae of the genus Flavivirus. The enzootic cycle is driven by continuous virus transmission to susceptible bird species through adult mosquito blood-meal feeding, which results in virus amplification. Species from the genus *Culex* mosquitoes (family Culicidae) are the primary amplification vectors. The transmission cycle exists in rural ecosystems and urban areas where the virus infects birds, humans, horses and other mammals. Most human infections occur in summer or early autumn. WNV is a vector-borne pathogen of global importance since it is the most widely distributed virus of the encephalitic flaviviruses.

Multiple factors impact the transmission and distribution of WNV, related to the dynamics and interactions between pathogen, vector, vertebrate hosts and environment. Hence, among other drivers, weather conditions have direct and indirect influences on vector competence, on the vector population dynamic and on the virus replication rate within the mosquito, which are mostly weather-dependent.

Ambient temperature plays an important role in the viral replication rates and transmission of WNV by affecting the length of extrinsic incubation, the seasonal phenology of mosquito host populations and the geographical variations in case incidence. Increased temperatures cause an upsurge in the growth rates of vector populations, decrease the interval between blood meals, shorten the incubation time in mosquitoes, accelerate the virus evolution rate and increase the viral transmission efficiency to birds.

The role of precipitation is more complex. Heavy rainfall increases the standing water surface which is necessary for mosquito larval development but might also lead to a negative association by flushing the ditches and drainage channels used by *Culex* larvae.

Below-average precipitation can facilitate population outbreaks of some species of mosquitoes because the drying of wetlands disrupts the aquatic food-web interactions that limit larval mosquito populations. Drought leads to close contact between avian hosts and mosquitoes around remaining water sources and therefore accelerates the epizootic cycling. Moreover, drought conditions can facilitate population outbreaks of some species of mosquitoes in the following year.

Recent climatic changes, particularly increased ambient temperature and fluctuations in precipitation, contributed to the maintenance (endemization process) of WNV in various locations in southern Europe, western Asia, the eastern Mediterranean, the Canadian Prairies, part of the United States and Australia.

Since predictions show that the current trends are expected to continue, for better preparedness, any assessment of future transmission of WNV should take into consideration the impacts of climate change.

### ***Infectious Disease Ecology and Epidemiology: Case study; The eco-epidemiology of Cutaneous Leishmaniasis caused by *Leishmania tropica* in Bethlehem villages***

**Ikram Salah;** Ben-Gurion University, Israel

Infectious diseases have become an increasing cause of morbidity and mortality during the last couple of decades. Since the 1970s there has been a resurgence of many vector-borne diseases including malaria, yellow fever, and West Nile virus and Leishmaniasis. Therefore, the combination between disease ecology and epidemiology can create a better understanding of how relationships of humans to their environment affects the way in which they come into contact and interact with the vector, and will allow us to better identify the weak links of disease transmission and target them for controlling the disease. Mathematical models such as SIR, representing populations of host and parasite that allow the analysis of the dynamics, spread, and control of infectious diseases. Control of zoonotic diseases may be best achieved using a multi-disciplinary approach. In the Palestinian West Bank, leishmaniasis is emerging as a serious public health issue. This case study was initiated to improve our understanding of the ecological, epidemiological and transmission dynamics of cutaneous leishmaniasis (CL) in the Bethlehem district of the West Bank. This unique study integrates public health measures, epidemiology and disease ecology at multiple scales. In this study sand flies were trapped in endemic area (AAR) and free-disease area (KIS) to compare activity patterns and population densities. The results showed that there was a significant difference in sand fly densities between sites, with densities being an order of magnitude higher in the endemic area. There was a significant effect of species in both sites; on average *Phlebotomus sergenti* was more abundant than *Phlebotomus papatasi*, with significantly higher abundance of *Phlebotomus sergenti* in AAR, and no significant difference in KIS.

Interdisciplinary approaches can help promote our understanding of disease transmission to humans. Study of the ecology of zoonoses and the link between epidemiology and ecology can provide a deeper understanding of zoonotic diseases.



### *Ecosystems Services and Health*

**Nadav Davidovitch**, Ben-Gurion University, and **Maya Negev**, Haifa University, "Public health aspects of ecosystem services".

**Ronit Endevelt** and **Yannai Kranzler**, Ministry of Health, Israel, "Food, health and ecosystems."

**Shirra Freeman**, The Hebrew University, Israel, "Agriculture, health and ecosystems."

**Alon Lotan**, HaMaarag, Israel, "Introduction to the Israeli National Assessment of Ecosystem Services".

**Shlomit Paz**, Haifa University, Israel, "Climate change, health and ecosystems."

**Dana Ziv**, Hebrew University, Israel, "Air pollution, health and ecosystems."

This session is devoted to public health aspects of ecosystems in Israel. The speakers are the authors of the Health Chapter of the Israeli national-scale ecosystem assessment (the I-NEA), an ongoing project initiated by HaMaarag, Israel's National Nature Assessment Program. The session will include a general introduction to ecosystem services and their health aspects, and then focus on the issues of climate change, agriculture, food and air.

I-NEA is modeled after the UK National Ecosystem Assessment. The assessment's main goals are to increase awareness of the multifaceted value of nature and our dependence on functioning ecosystems; and to assist managers, decision- and policy-makers in incorporating the value of ecosystem services and biodiversity into planning, land management and policy. The I-NEA will present a comprehensive picture of the current state and trends of Israel's ecosystem services across all ecosystem types, their value (economic, social and health), the biodiversity involved in service provision, drivers of change affecting service provision, and management and policy response options. This assessment is based on integration of existing data and information collected from a wide range of sources, and is performed by over a hundred Israeli scientists and experts from a variety of disciplines.

According to the UK-NEA, Ecosystem services positively influence our health by providing basic survival resources (such as clean air, water and genetic resources for medicines), as well as raw materials for industry and agriculture. Epidemiological studies have shown that ecosystem services contribute to better mental and physical well-being, through recreational access and proximity to a natural environment.

The session will include an introduction to ecosystem services assessments and the Israeli context, followed by a general introduction to the health aspects of ecosystem services. Then, the authors of the health chapter of the I-NEA will present the fundamental health aspects of ecosystem services globally, with initial findings from the Israeli context.

## **Public Health Workshop**

### *Participatory action research using mobile methods*

**Colin MacDougall**<sup>1</sup>, **Nadav Davitovitch**<sup>2</sup>, and **Maya Negev**<sup>3</sup>

<sup>1</sup>Flinders University, Australia

<sup>2</sup>Ben Gurion University, Israel

<sup>3</sup>Haifa University, Israel

Climate change is one of the biggest problems we have ever faced (and created!). We need the best science to explain the causes and develop solutions: but in doing so we need the combined wisdom of scientists, Indigenous groups, community organisations and citizens. The most immediate results of climate change included new patterns of diseases, re-emergence of old diseases, and increased death and trauma from natural disasters. Health research works best when there is a respectful partnership, leading to concerted action, between professional scientists and various community groups and representatives – a field known as Participatory Action Research (PAR).

PAR can make a useful contribution to participatory research about the health effects of climate change because its roots are in emancipatory causes and social movements, seeking to empower communities in general, and the

marginalised in particular. PAR has often used qualitative and ethnographic methods. Over the past decade or so, PAR started to use photographic methods, enabling participants in research to have more control in selecting and describing what is important to them. At the same time, participant-guided mobile methods (such as walks and driving) emerged with a similar goal of changing the power relations between researcher and researched. Mobile and photographic methods are now used in tandem to examine the aftermath of natural disasters, which will become more prevalent as the climate changes.

This workshop starts with an overview of theoretical foundations that need to be understood in order to plan rigorous and ethical research. The majority of the time will be spent in a practical session on campus experimenting with mobile and photographic methods. The final part of the workshop will bring together theory and practice so participants will be able to start using these methods in research on climate change and desertification.

## Remote Sensing

### *Using Visible Spectroscopic Based Analytical Methods for Assessing Labile Carbon on Agricultural Areas*

**Jintaridh Bunjirtluk**<sup>1</sup> and P.P. Motavalli<sup>2</sup>

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This study was conducted to develop the fundamental relationship between soil's organic matter and its visible reflectance spectra. Soil samples were collected from 0-20 cm depth for analysis. Labile Organic carbon in each sample was analyzed by using permanganate-oxidizable C (KMnO<sub>4</sub>) method in a laboratory and in the field. Visible reflectance spectra of the samples were measured by a spectrophotometer in the 550 nm. Soil samples were compared from degraded and non-degraded areas, and also different landscape positions were studied. Methods using KMnO<sub>4</sub> solution to oxidize labile C in order to assess soil quality have been developed, including field and lab methods. The field-kit and laboratory methods were compared, and also the relationship of KMnO<sub>4</sub> oxidized C with total soil organic C, and particulate organic C was determined. The results showed that the field method was as accurate as the lab method in all sites. The relationship of total soil organic C and KMnO<sub>4</sub> oxidized C was highly correlated in all sites. Meanwhile, the relationship of particulate organic C and KMnO<sub>4</sub> oxidized C was less correlated compared to total soil organic C. This study also tested how management practices influence soil organic carbon. Results showed that labile C increased the fallow year. The non-degraded soils had higher labile-C than degraded soils. Comparing labile C in cultivated and non-cultivated areas with each landscape position was also studied and showed that cultivated areas have more labile than non-cultivated areas. Labile C was higher in summit, toeslope and footslope than shoulder, and backslope in non-cultivated areas, but it showed no difference in cultivated areas.

### *Modeling Shrublands Biomass Using Radar Polarization Parameters*

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Mapping shrubland biomass is important for better understanding Mediterranean and semi-arid/arid ecosystem changes and their response to desertification and global warming. However, field information on shrubland biomass is scarce due to technical limitations regarding data collection, which, when combined with the high geodiversity of desert fringe ecosystems, hamper characterizing biomass changes over wide regions which are characterized by both spatial and temporal dimensions.

Remote sensing may provide an adequate means for mapping biomass by the recent availability of multi-sensor systems with improved spatial and temporal resolutions based on long-term monitoring and repetitive data. The Normalized Difference Vegetation Index (NDVI) based on multi-spectral has been widely used for biomass estimation at semi-arid/arid regions. However, the NDVI has several disadvantages; influence by atmospheric influences, limitation of monitoring the top of the canopy, and saturation problems at some levels of vegetation densities. The low frequency of radar sensor (L-, P-band) penetrates deeper into the canopy layer so it provides a wider dynamic range of saturation than an optic sensor. Especially, the polarimetric SAR (PolSAR) characteristics make them very useful for indicating volume scattering from vegetated regions and it contains information about geometrical structure and geophysical features. However, most existing remote sensing techniques for biomass estimation were tested for forest area and agriculture crops having a homogenous characteristic or simple structure of forest, and were not tested for semi-arid natural scenes having high geodiversity because of their complexity. Accordingly, the aim of this study was to develop modeling shrubland biomass using L-band polarimetric SAR data. Every radar parameters (intensities, intensity ratios, polarization parameters, phased differences, radar vegetation indices) were examined based on multiple regression technique. For evaluation/validation, three different types of biomass models were used: patch pattern biomass model from a high resolution orthophoto, NDVI:R model from multi-spectral imagery with rainfall, and allometric measurement from field measurements.

### ***Evaluating and predicting water consumption by irrigated agriculture in the semi-arid regions of the north-western Negev, Israel***

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One of the world's most vital needs is a stable supply of food and water. Both food and water revolve around agriculture: being the world's largest fresh water user, and cardinal food supplier. In order to provide the agricultural sector with the appropriate amount of water that will guaranty its sustainable function, it is important to estimate future agricultural water needs. Therefore, it is important to understand the dynamics in agricultural Land Use Land Cover (LULC) change. To better understand the rules that govern change, it is necessary to investigate the past dynamics in agricultural lands, connect these changes to the drivers and extrapolate future change according to forecasted future reality thus allowing the application of appropriate adaptation measures.

In this research, detection of agricultural lands in the semi-arid to arid northwestern Negev for the years 1972-2013 was executed, using 46 intra- and inter-annual Landsat MSS Tm and ETM+ images. Classification results were compared to three reference LULC maps, with overall accuracy of 86%. Using these findings, a correlation of agricultural spread with water availability, irrigation infrastructure, road infrastructure, soil type, and geographical parameters was conducted, along with interviews with agricultural experts aiming to examine the farmers' decision making processes. These data were then translated into rules that dictate agricultural expansion, and inserted into a high resolution spatially explicit model using Cellular Automata and Agent Based techniques that enable the prediction of the future development of agricultural areas, given different scenarios of prevailing conditions. The model's results show that agricultural expansion in the northwestern Negev is highly dependent on water availability and that the spatial expansion patterns are mostly influenced by irrigation and road infrastructure positioning and placement. This model, being highly encapsulated and object oriented in nature can be reused in different settings with minimal adaptations.

### ***Remote sensing of evapotranspiration over irrigated farms in central Arizona, USA***

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Accurate estimation of evapotranspiration (ET) is needed to identify crop water stress, help assess effects of differing irrigation practices, and provide information needed to improve agricultural water management. Remote sensing provides important ways to map ET and meet these needs. However, the trade-offs between model complexities, data

requirements and modeling accuracy are not well known. Specifically, comparative benefits between ET approaches based on vegetation indices, such as NDVI, with those based on surface energy balance have not been adequately evaluated. If NDVI-based ET estimates have uniformly high accuracy and consistency, then future remote sensing platforms could be designed for higher spatial and temporal resolutions at relatively lower cost. On the other hand, if energy balance models resolve critical water stress events that would otherwise be undetected, then future designs need to include higher-cost land surface temperature mapping capabilities. To help understand the ramifications of each approach, a study was undertaken to compare two remote sensing ET models. One was an inverse biophysical technique that uses satellite-based NDVI data and the Simple Biosphere model, SiB2. The other was a surface energy balance model based on both satellite NDVI and land surface temperatures (LST). Remote sensing data, including land use and cover types, and ground-based water use data were collected over the Eloy Irrigation District in Central Arizona, a 40 km x 40 km region encompassing approximately 35,000 irrigated ha. Using crop classifications for the predominant crops, namely cotton, wheat and alfalfa, the two modeling approaches were applied to observations in 2008. Comparative ET results will be discussed.

***The NASA land-cover and land-use Change program: Focus on drylands***

**Garick Gutman**, NASA, USA; ggutman@nasa.gov

This presentation will first briefly describe the NASA LCLUC program, its scientific content and its global nature. The talk will focus on LCLUC issues in drylands of the globe, and describe the past and current projects. It will include urban studies, water resources and agriculture management, climate impacts and human dimensions. Then, the presentation will briefly summarize what we have learned up to date scientifically and what remote sensing assets and methods are being used in the program as well as what is being planned in the near future. The LCLUC program's support of international regional programs and some programmatic achievements under the auspices of these programs as far as drylands are concerned will be discussed. The talk will conclude by presenting the scientific vision, programmatic developments and opportunities for enhancing collaboration between NASA LCLUC and international communities.

***Present, past and future of global distribution of Pistacia species in relationship to climate change - remote sensing and GIS analyses***

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Environmental conditions are the limiting factors for vegetation development. It is hypothesized that changes in global distribution of plant species over geological periods reflect the climatic changes over time. This relationship is potentially useful in prediction of the most suitable areas for forestation. Changing climate can force sufficient plant species to migrate into more suitable areas, therefore global or regional climate change episodes are consequently followed by various distribution patterns of flora.

Forests play an integral part in carbon and water cycles, they provide timber, food and other products, and they are home to a vast diversity of plants, animals and microorganisms. Forests occur in a wide range of climatic conditions, thus it is challenging to predict how the vulnerability of trees to changes in water availability and temperature compares between different biomes. In this work we focus on the eleven species of the genus *Pistacia*. Four species of the genus, *P. atlantica*, *P. lentiscus*, *P. terebinthus* and *P. palaestina* are native to the Mediterranean region; *P. khinjuk* and *P. vera* are native to central Asia; *P. chinensis* and *P. weinmannifolia* - eastern Asia; *P. texana*, *P. mexicana* northern America and *P. aethiopica* – East Africa.

The global distribution of species of the genus in relation to different climate zones was done by analysis of remote sensing and Geo-statistics. Geographically distinguishable *Pistacia* species also differ in tolerance to various harsh

environmental conditions. Geostatistical, with corresponding spatial and climate analyses, showed limited distribution centers of the genus by various environmental parameters. Probability distributions, result of global distribution models using climate, landscape and soil parameters in the present, past and future periods showed migration pathways according to the climate change, contributing to the process of reforestation and conservation of *Pistacia* genus. Additionally, biochemical composition of leaf and bark of the trees appeared to be an appropriate variable for species classification in phylogenetic clusters. There was high correlation between the first derivative of the spectral reflectance of specific portions of the reflectance spectrum and biochemical content in the plants. Also, variation within the phenology cycle appeared to be a significant factor for classification of species when up-scaling the data from hyper-spectral to multispectral resolution. They showed not only distinctive classes of the different species but also phylogenetic patterns.

### ***Re-greening of the Sahel - A myth? Case studies from Mali, Niger and Darfur/Sudan***

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The actual desertification debate highlights two contrasting views: the paradigm of an “encroaching desert” and the more recent view of a re-greening trend. The main arguments supporting a re-greening trend in the Sahel are:

- 1) Remote sensing data (generally AVHRR-NDVI) for the period after the last severe drought (1982-1984) seem to show an increase in vegetation;
- 2) Increase in precipitation controls Sahel-greening; and
- 3) Farmers have changed their local management techniques and are responsible for re-greening in the Sahel.

The focus of this presentation lies on the basic question how to distinguish system fluctuations from real system changes. To tackle this question, plant species’ composition (actual and past (1950s/70s)) were assessed in the field and vegetation dynamics in multi-temporal satellite images since 1970s were analyzed. Density and distribution of woody vegetation provide the best information for evaluating system changes. Additional information sources are rainfall distribution data, questionnaires for local population and historical data.

Landsat satellite data for a selected region in Mali (Canal du Sahel) show a recovery from the 1980s drought (first re-greening argument). However, analysis of 1970s data (despite drought situation) indicates that this “recovery” in reality is a strong decline in savanna vegetation density. The “greening” effect observed after the last drought can be seen as a documentation of well-known fluctuations, including system’s resilience to recovery after drought phases. The question is to what extent the vegetation had been recovered?

Satellite data of the 1970s and even 1980s also indicate the former presence of dense savannas in different areas in Niger, Darfur/Sudan and also Mauritania and Chad (not presented here). Actual field work in North- and West Darfur confirm a dramatic change in species composition compared to the 1960s and 1970s. Recent satellite data analysis of the entire Darfur region (1970s, 2000 and 2010) shows a strong decline in woody vegetation density and increasing fragmentation. These results are discussed as real system changes.

According to new analysis of rainfall dynamics, various authors confirmed some degree of recovery since the drought periods of the 1970s and 1980s but also changes in rainfall characteristics. They evaluated the increase in rainfall as considerably inferior in comparison to the rainfall amount of the first half of the 20th century.

Farmer-led innovations are discussed as major sources for the observed re-greening in some areas, particularly in parts of the South Sahel in Burkina Faso and Niger. Likewise, the system’s ability to recover in combination with anti-erosion measures result in a restoration of traditional agro-forestry systems. These encouraging results should not be labeled as re-greening of the entire Sahel region. Huge areas of the Sahelian region are still undergoing severe degradation/desertification processes.

### ***Structural changes of desertified and managed shrubland landscapes in response to drought: Spectral, spatial and temporal analyses***

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Drought events cause changes in ecosystem function and structure by reducing the shrub abundance and expanding the biological soil crusts (biocrusts). This change increases the leakage of nutrient resources and water into the river streams in semi-arid areas. A common management solution for decreasing this loss of resources is to create a runoff-harvesting system (RHS). The objective of the current research is to apply geo-information techniques, including remote sensing and geographic information system (GIS), on the watershed scale, to monitor and analyze the spatial and temporal changes in response to drought of two source-sink systems, the natural shrubland and the human-made RHSs in the semi-arid area of the northern Negev Desert, Israel. This was done by evaluating the changes in soil, vegetation, and landscape cover. The spatial changes were evaluated by three spectral indices: Normalized Difference Vegetation Index (NDVI), Crust Index (CI), and landscape classification change between 2003 and 2010. In addition, we examined the effects of environmental factors on NDVI, CI, and their clustering after successive drought years. The results show that vegetation cover indicates a negative  $\Delta$ NDVI change due to a reduction in the abundance of woody vegetation. On the other hand, the soil cover change data indicate a positive  $\Delta$ CI change due to the expansion of the biocrusts. These two trends are evidence for degradation processes in terms of resource conservation and bio-production. A considerable part of the changed area (39%) represents transitions between redistribution processes of resources such as water, sediments, nutrients, and seeds on the watershed scale. In the pre-drought period, resource redistribution mainly occurred on the slope scale, while in the post-drought period, resource redistribution occurs on the whole watershed scale. However, the RHS management is effective in reducing leakage since these systems are located on the slopes where the magnitude of runoff pulses is low.

### ***Monitoring dynamics of grassland resources in southeast inner Mongolia and Great Wall Region, China***

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Southeast Inner Mongolia and Great Wall region is a notorious arid and semi-arid region dominated with vulnerable grassland and dryland ecosystems in north China. The region has long been recognized as the main source of frequently-occurred sand-and-dust storms sweeping through Beijing and Tianjin to north China during the 1990s and early 2000s. In order to reduce the sand-dust storm disasters threatening north China especially the capital Beijing and the big city Tianjin and to maintain a sustainable development in the region, Chinese government launched a giant environmental project in 2002 to protect the grassland ecosystems and to afforest the low mounts in the region. The 1st stage of the project was scheduled to implement for a period of 10 years from 2002 to 2012. Total investment of the project had exceeded 41 billion RMB (about US\$6 billion) during the project period. The project was implemented in 75 counties, which can be divided into 4 sub-regions: northern arid grassland sub-region, Hunshandak sandy land sub-region, Great Wall dryland sub-region and Yanshan Mountain sub-region. The objective of the study is to monitor the dynamics of grassland resources in the project region covering southeast Inn Mongolia, north Hebei and Shanxi provinces, and north Beijing and Tianjin cities. MODIS data were used for the monitoring and NDVI was computed from MODIS data. Five aspects of grassland resources were then computed from NDVI and relevant data for the monitoring: vegetation growth status, grass production, vegetation cover fraction, and desertification percentage and cattle loading capacity. The year 2000 was used as a reference for the monitoring. Our results indicate that vegetation growth status was gradually increased during the 2001-2009 period. The excellent status accounted for 30% in 2009 while it was only 20% in 2000. As a contrast, the worst grassland accounted for 27% in 2009 in comparison to the 42% in 2000. During the period 2000-2009, the grassland yield increased about 324kg/ha on average in the region. During the period it seems that total acreage of grassland did not remarkably change. Average vegetation cover fraction also experienced an increase of ~7% during the period, featuring the obvious declination of low grass cover acreage and remarkable increase of the dense grass area. As to the desertification percentage, severe desertified grassland shows a trend of delineation and undesertified grassland has an obvious increase. All these implied the grassland and dryland ecosystems were in recovering evolution. The cattle loading capability of the region has steadily increased from ~2630/km<sup>2</sup> in 2000 to above 3100/km<sup>2</sup> in 2009. The number of cattle-overloading

counties decreased by 13 countries from 2000 to 2009. Therefore, we conclude that the environmental conditions in the region have obviously improved during the period. As a result, the sand and dust storms invading north China have also weakened in recent years.

### ***Monitoring for drivers of land degradation using remote sensing and GIS in Mongolia***

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Remote Sensing and GIS were used to monitor interactions and relationships between land use and land cover changes in the regional ecology area of Umnugobi province (South Gobi). This study aims to determine the land degradation conditions in 15 soums (administrative units) of the study area, Umnugobi province. Using GIS processing of data climate drivers (precipitation, air temperature), vegetation data and socio-economic drivers (livestock numbers, population figures, mining activities) were analyzed. We focused on developing a modeling approach for monitoring land degradation using GIS and Remote Sensing tools by integrating natural and socio-economic data. The Moderated Soil Adjusted Vegetation Index (MSAVI) from SPOT/VEGETATION was used to determine vegetation cover change for the period 2000 to 2013. Landsat data for the years 2000, 2010 and 2013 were analyzed to derive and classify “hot spot” areas of land degradation. GIS conditional functions were used for mapping and analyzing climate and socio-economic driving factors, both of which affect land degradation. Conditional functions such as MAP-Algebra from ArcGIS were developed using ground truth data and data from National Statistics. Our study documents that 60 percent of the study area is affected by land degradation caused by human and climate drivers.

### ***Drought monitoring in Northeast China using an improved Temperature Vegetation Precipitation Index (iTVPI) based on MODIS imagery and meteorological data***

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Northeast China, one of the most important grain producing regions in China, is vulnerable to drought due to its high fluctuation of monthly rainfall. Timely, accurate and effective monitoring of drought in the region is very essential to secure its output of grain production. In this paper, an applicable approach for drought monitoring was developed which is based on the improved Temperature Vegetation Dryness Index (iTVDI) established according to the relationship between the difference of land surface temperature minus air temperature and the Normalized Difference Vegetation Index (NDVI). Since precipitation had a significant impact on drought, we combined the improved Precipitation Distance Index (iPDI) into the iTVDI to generate an improved Temperature Vegetation Precipitation Index (iTVPI) for drought monitoring in Northeast China. To validate the approach, we computed the iTVPI for the region using MODIS data products and meteorological data from April to July of 2003, the growing season of spring wheat in the region. According to the iTVPI, drought conditions were assessed into five grades: severe drought, moderate drought, slight drought, normal condition, and wetness. The results showed that drought was different in the region during the period because different climatic zones and different land cover types had different magnitudes of drought severity. The iTVPI had a close correlation with soil moisture (SM) (10 cm SM,  $R^2 = 0.79$  and 20 cm SM,  $R^2 = 0.67$ ), which demonstrated that the approach was suitable for real-time drought monitoring in the region.

### ***Some results of space monitoring of droughts in Kazakhstan***

**Lev Spivak**, International University of Nature, Society, and Man; Russia; levspivak@mail.ru

Strengthening of continental climate, increase of the incidence of adverse and extreme weather events such as drought are typical events for Kazakhstan in the last decade. Main areas of crops are located in the northern regions of Kazakhstan; they are non-irrigated. Therefore, they are characterized by a strong dependence of the yield on the weather. Droughts of varying intensity and duration are observed almost every year in the country. They lead to a sharp decrease in the yield of agricultural products, violation of the mode of functioning of pasture and cause significant damage to the economy of the Republic.

Space monitoring of drought has been held in Kazakhstan since 2000. To do this, a special set of technologies were developed at JSC "National Center of Space Research and Technologies" of Space Agency of the Republic of Kazakhstan. Recognition of dry weather conditions on Kazakhstan territories and monitoring their subsequent development are carried out using differential and integral vegetation indices that are calculated from satellite images of low resolution. The base for calculations is a time series of ten-days composites of NDVI.

Results of drought space monitoring are mapping of the current state of crops and natural vegetation, defining signs of drought and detection of areas with drought, controlling the development of arid conditions, identifying trends and directions of propagation of drought, analyzing spatial and temporal patterns of development of drought over many years and quantifying the frequency of droughts.

The analysis of time series of vegetation indices allows early identification of drought on the basis of remote sensing data. For arid and semi-arid zones of Kazakhstan, the early onset of the peak of vegetation associated with the early spring and the rapid disappearance of the snow cover is one of the key signs of impending drought. Also, low values of maximum vegetation peak are fixed for dry years.

In the last decade a tendency to increase the number and intensity of droughts is noted. Since 2004 vegetation cover of Kazakhstan as a whole is under the stress impact of weather. According to satellite data, droughts of varying intensity arise almost every year. In 2006, almost the entire territory of Kazakhstan was in stress conditions (excluding northern regions) and in 2008 - the central and eastern regions, in 2010 - the western and northern regions of the Republic, and in 2012 the most severe drought throughout the period of monitoring was registered.

The satellite monitoring results are used to estimate the risk of drought. Risks are calculated taking into account the frequency of drought, which was registered during the observation period. Prior probability of drought conditions can be calculated for any part of the territory of Kazakhstan (region, district, farming, field). To improve the accuracy of estimates of the probability of occurrence of droughts involved information about other factors that affect the state of vegetation (snow, temperature and other), including weather conditions in the preceding season.

### ***Using time series of satellite vegetation indices for analyzing of the dynamics of vegetation degradation in Kazakhstan***

**Lev Spivak**, International University of Nature, Society, and Man; Russia; levspivak@mail.ru

Studies conducted by climatologists in the preparation of the Second National Communication of Kazakhstan on Climate Change indicate that the temperature regime in Kazakhstan is changing, mainly as warming. The increase of temperature is observed almost everywhere and in any time of year. Meteorological changes lead to responses of ecosystem and, primarily, the vegetation cover, as the most dynamic component. Degradation of vegetation cover and deterioration of its condition are the most important and visually identifiable effects of desertification processes.

Lands with degradation of vegetation are well detected by remote sensing data. Use of satellite data is currently the most effective way to study the transformation of plants under the influence of climate change on various sized territories..

It is advisable to use the integral vegetation indices to quantify estimated and comparative analysis of the long-term changes of inter-annual variations of the impact of seasonal weather conditions on vegetative productivity. Integral vegetation index (IVI) characterizes the total aboveground biomass during the growing season in each pixel and can be calculated for objects with different spatial dimensions. Integral index of vegetation conditions (IVCI) allows to compare the effect of weather conditions of season on the state of the vegetation and to rank years relatively strength of stress on vegetation. The method of constructing maps of IVI and IVCI allows for the analysis of the dynamics of vegetation productivity change for all sized territories..

Values of IVCI <0,3 is criterion of drought vegetation season for any area and characterize the stress state of vegetation. The analysis of IVCI values shows that on the territory of Kazakhstan, the wettest season by the weather conditions is 2002 year for the period 2000-2013. According to satellite data, every second year is dry since 2004. The degree of the impact of drought on the productivity of vegetation is constantly increasing. There is a general tendency



of decreasing of the values of integral indexes (IVI and IVCI) in the period 2000-2013, both for the republic as a whole and for its various parts. This fact is a characteristic of stress amplification of weather impact on the productivity of vegetation.

For each region of the Republic, a perennial distribution of IVCI- index was built. The equation of the linear trend for the time series values are calculated as  $IVCI(t) = k * t + b_0$ . Values of k-coefficient in the equation of the linear trend show the rate of decrease of IVCI. Similar calculations allow zoning territory of the Republic on the degree of deterioration of vegetation in the vegetation season at the scale province or district. The greatest degree of deterioration of vegetation noted was in south-western regions of Kazakhstan.

### ***Change detection in drylands: validity of the Tasselled Cap transform***

**Anna Zanchetta**, Universita' di Bologna, Italy; anna.zanchetta@unibo.it

The Tasselled Cap (TC) transform refers to the transformation introduced by Kauth and Thomas in 1976, sometimes also called Kauth-Thomas (KT) transform. Their study, based on the analysis of Landsat MSS images of a small crop field sample in the United States, investigated the vegetation and soil spectral reflectances in the bands-space in a multi-temporal scale. Following the vegetation growth from the bare soil up to plants senescence, the time evolution of the pixels position on the bands-space showed a shape of a tasselled cap, hence the technique's name.

The principle of TC consists of a linear transformation of the image pixels' values to convert the original correlated bands to a new set of uncorrelated axes. The new axes bear a physical meaning in terms of the characteristics of the surface: Brightness, Greenness and Wetness. Unlike Principal Component Analysis (PCA), TC transform is not image-dependent and can be used for Land Use Land Cover Change (LULCC) change detection techniques, like the Change Vector Analysis (CVA).

A widespread use of the TC coefficients is present in literature. However, the application for desert areas is still to be investigated. The development of new parameters for dryland conditions and their application for LULCC studies is presented, assessing the validity of this tool for desert studies.

## **Rethinking Agricultural Technologies**

### ***Sustainability Innovations in Project Wadi Attir***

**Michael Ben-Eli**, The Sustainability Laboratory, USA

Project Wadi Attir is a groundbreaking initiative of the Bedouin community in the Negev, for establishing a model sustainable agricultural operation. The project was initiated by The Sustainability Laboratory, a US-based non-profit, and the Hura Municipal Council, the governing body of a local Bedouin township. Designed to leverage Bedouin traditional values, aspirations, know-how and experience with modern-day science and cutting edge technologies, Project Wadi Attir showcases implementation of holistic sustainability principles developed by The Lab. It demonstrates an approach to sustainable development in an arid environment, valid and replicable locally as well as in other similar regions around the world.

The core of the project includes an organic farming enterprise involving animal husbandry and the production of dairy products; cultivation of medicinal plants and the development of a related line of health products; and the reintroduction of nutritious, indigenous vegetables to common use. At its heart, the project will include a visitor, training and education center, with a focus on ecology, sustainability innovation and entrepreneurship. The project site will be supported by an integrated infrastructure of green technologies including a soil enhancement program; solar energy and bio-gas production; the production of compost from organic waste; advanced irrigation management; and waste water treatment and recycling.

Implementation of the project has been supported by a uniquely broad coalition involving a government consortium led by the Ministry of Agriculture and Rural Development and including the Ministry of Development of the Negev and the Galilee, the Economic Development Authority in the Minority Sector, at the Prime Minister's Office, and the Authority for Development and Housing of Bedouin in the Negev, as well as researchers from the Ben-Gurion University of the Negev, JNF-KKL, local NGOs and Kibbutzim, private sector enterprises, foundations, and individual donors.

This talk will present an overview of this ground breaking community-based, model for sustainable agriculture in an arid environment. The presentation will emphasize the underlying, whole system approach to development, the core sustainability principles that inform the project's design, the key functions which together make this project a unique initiative, and the project's current state of development.

***Alternative technologies and landscape planning for local development: A case study and pilot project for water management and biodiversity conservation in the Atacama Desert***

**Martino Correggiari**, International Center for Cultural Landscapes Studies (CISPC), Italy

The major issues of the Atacama Desert concern soil degradation, loss of biodiversity, over-exploitation of scarce resources and abandonment of rural areas by the population. The territory is characterized by a high level of aridity and water scarcity, where some areas never get any rainfall. But the arid landscape shows situations in contrast with the ecological predominant model, like the phenomenon of the oceanic fog that allows the existence of particular and fragile ecosystems, defined Fog Oases.

The oceanic fog is a local resource that can be also used by means of a simple technology called "Atrapaniebla", to generate drinking water for different vital activities, like reforestation, proximity agriculture and certainly human consumption. This technology has been used for a few decades in isolated cases in the Chilean and Peruvian Desert, including projects with entire villages and activities in support of the rural population.

The case study is focused on an area of the Atacama's coast, called Alto Patache Fog Oasis, an important ecological site protected and managed by a scientific research center: the "Centro del Desierto de Atacama". There, the center installed a small research station and some fog collectors (atrapanieblas) for conservation, research activities and environmental education. The environmental context of the Oasis is characterized by other ecological sites, small fishing villages and an important industrial port.

The pilot project aims to expand the opportunities for local development and relationship between the use of technology, the implementation of services for the Center and the needs/activities of the nearest rural community. At the same time the purpose is to reflect about the role of landscape planning through the interaction between institutions and the subjects living in the territory, and to propose a landscape plan and specific interventions for the local area, managed by the Research Center.

The importance of territorial planning that allows local and sustainable development for the landscape heritage is synthesized in the relationship Landscape – Research Center – Community, where biodiversity conservation, the use of resources and the planning of interventions coexist, in their environmental and productive aspects.

The phenomenon of the oceanic fog and the experimentation with the technology is quite common in drylands around the world. The pilot project aims to show a way, not to solve the problems of degradation and water availability in all kinds of drylands, but to offer ideas for local development, based on criteria of environmental planning.

***From transfer to translation: Using systemic understandings of technology to understand drip irrigation uptake***

**Yaakov Garb<sup>1</sup>** and **Lonia Friedlander<sup>2</sup>**

<sup>1</sup>Ben-Gurion University, Israel

<sup>2</sup>Stony Brook University

Drip irrigation is a technology with great potential for improving the efficiency of water use, and for increasing crop production and food security by enabling agriculture on marginal land. Yet drip irrigation's uptake is patchy, with conspicuous successes in some locations and failures in others. In this paper we compare the history and

circumstances of the mostly failed uptake of drip technology in sub-Saharan Africa with those of its deep and robust uptake in the Israeli context in which many of the failed African systems originated. We do this not only to throw light on the contextual dependence of this particular technology, and highlight strategies that have been attempted to protect it from this dependence, but also, more broadly, to use the notion of “technology translation” to consolidate several streams of socio-analytic thinking that offer improved understandings of how technologies evolve and travel. Israel has long been a major player in the development and distribution of drip irrigation, with exceptionally extensive national level uptake. We suggest that this emerged from an integrated technology innovation system with a capacity for ongoing multi-leveled learning and dynamic evolution of the technology in light of context-specific potential and problems. Conversely, the failed uptake of drip irrigation in many sub-Saharan African countries can be viewed as a consequence of the transfer of static physical artifacts into new contexts lacking similar local systems into which these could be absorbed and evolve (re-innovated). We interpret two contrasting attempts to boost drip irrigation adoption as efforts to overcome this dependence: simplifying the hardware to become system-free, or creating a kind of remotely operated autonomous small-scale innovation system in which self-contained installations are bundled with resources and linkages to a directing hub.

Drawing on several vibrant streams of literature in the sociology of technology and technical innovation, we suggest that the emerging metaphor of “technology translation” provides a better way of thinking about and improving what happens when technologies such as drip irrigation travel to new settings. Technology translation, rather than transfer, suggests a more dialogical approach emphasizing learning and using the local “languages” of the contexts into which artifacts will be translated, making artifacts supple enough to be readily modifiable within these, and finding ways to bolster the local innovation systems that will re-invent and re-link them into new relationships.

### ***Adoption of water saving technologies in drylands agriculture - what will it take? Evidence from Western India***

**Ram Fishman**, George Washington University; USA

Despite the rapid depletion of India's groundwater resources and escalating use of energy for pumping, the great majority of Indian farmers continue to flood-irrigate their fields and the rates of adoption of water-saving cultivation technologies remain low. Opinions differ on the causes of this disparity and what may be necessary to resolve it. Some believe increasing scarcity will eventually lead farmers to adopt such technologies, whereas some argue that proactive extension and subsidy programs are required, while still others argue for better incentives, including the accurate pricing of water and energy. This talk will report some results from field studies in Northern Gujarat, one of the country's most groundwater depleted areas, that provide some evidence on these issues. A pilot of a novel reform with the Government of Gujarat revealed that while voluntary metering and marginal billing of farmers is possible, it didn't seem to affect farmers' water usage. Comparisons of household behavior between villages with different degrees of scarcity (driven by plausibly exogenous variation in geology) revealed that households fail to adapt to increased scarcity, and instead choose to reduce their cultivation, exit from agriculture, and migrate. Finally, a well-designed subsidy program has led to a rapid diffusion of drip irrigation in the area, and preliminary results on its impacts will be presented.

## **Soil and Land Restoration**

### ***Appropriate integrated nutrient management and water harvesting options for maize production in the semi-arid southern rangelands of eastern Kenya***

**Cyrus Githunguri**, Kenya Agricultural and Livestock Research Organization, cyrusgithunguri@yahoo.com

The Southern Rangelands of Kenya are prone to frequent droughts and crop failures leading to serious food shortages. The effect of the farmer practice (flat seedbed), tied-ridging and contour furrows water harvesting techniques and five integrated nutrient management practices on the performance of rainfed maize was studied on-station (Katumani) and on-farm at the southern rangelands of Kenya (Kibwezi) during the short rains season. Both shelled and unshelled maize yields responded positively to both water harvesting techniques and integrated nutrient management options. Under water harvesting techniques, the tied ridging had the highest positive effect on grain yield. Among the integrated nutrient management options, manure at either 5 or 10 t ha<sup>-1</sup> plus 20 kg N plus 20 kg P<sub>2</sub>O<sub>5</sub> kg ha<sup>-1</sup> had the most positive effect on maize yields. A combined application of manure and inorganic fertilizers has a highly positive on maize yields. In the absence of inorganic fertilizers, a minimum of manure at 10 t ha<sup>-1</sup> should be applied on maize plots. The tied-ridging water harvesting technique should be recommended to farmers in the Machakos and Kibwezi in the southern rangelands of semi-arid Kenya.

### ***Response of soil microbial communities to vegetation rehabilitation in semiarid sandy land***

**Yu Jun**, Institute of Applied Ecology, Chinese Academy of Sciences, China, yujun@iae.ac.cn

The combination of irresponsible human activities (e.g., over-reclamation or over-grazing) and the unpredictable abiotic changes of climatic features (e.g., drift potential and frequency of sand-driving winds) have caused rapid soil degradation or desertification in semiarid areas of North China over the past 50 years. Planting indigenous shrub and/or semi-shrub species, such as *Caragana microphylla*, *Salix gordejvii* and *Artemisia frigida*, on active sand dunes in semiarid sandy lands, has been implemented since the 1950s, and has proven to be an effective approach to control desertification and promote vegetation rehabilitation. With the growth of planted (semi)shrubs, the secondary plant communities have become more diverse, and soil physicochemical properties (including silt and clay content, water-holding capacity, soil organic carbon, total nitrogen and phosphorus, and effective phosphorus and potassium contents) subsequently improved. However, our knowledge of the response of soil microbial communities to vegetation recovery in semiarid sandy lands of North China is limited, especially in the aspects of microbial genetic and functional diversity. In order to determine the variations in ecological functions of soil microbial communities during vegetation rehabilitation in semiarid areas of North China, a two-year study was initiated on the Horqin sandy land of Inner Mongolia in August 2013. Soil samples were taken from the top layer (0-10 cm) under the canopy of *C. microphylla* shrubs planted in 1984 and 2002, and under the native *C. microphylla* shrubs; moreover, soils from the open spaces between the shrubs in each sampling area and from the top layer of active sand dunes were collected as controls. Substrate-induced respiration, representing microbial functional diversity, was determined using MicroResp™ plates. The basal respiration and biomass of soil microbial communities ranged from 0.06 to 0.17 µg C-CO<sub>2</sub> g<sup>-1</sup> dry soil h<sup>-1</sup> and from 7.0 to 58.0 µg C g<sup>-1</sup> dry soil, respectively, and an apparent increasing trend in both parameters was observed along a chronosequence of planted *C. microphylla* shrubs regardless of the sampling site (i.e., under the canopy of shrubs or at the open spaces). The utilization rates of the four carbon groups, i.e., amino acids, aromatic acids, carbohydrates, and carboxylic acids, were 0.13-0.78, 0.02-0.21, 0.14-2.04, and 0.15-1.36 µg C-CO<sub>2</sub> g<sup>-1</sup> dry soil h<sup>-1</sup>, respectively. The time of vegetation establishment exhibited a significant (p<0.001) influence on the utilization rate of each carbon group, while the sampling site was found to significantly affect (p<0.05) the utilization of amino acids. Redundancy analysis showed that without vegetation, i.e., active sand dunes, explained 36.2% of the variations in utilization rate of carbon sources (p<0.01). Moreover, native vegetation (10.4%) and the time of vegetation establishment (5.6%) were also significantly (p<0.01) related to changes in carbon utilization rates. Specifically, microbial communities colonizing soils under the canopy of planted *C. microphylla* shrubs had an affinity to glucose, galactose, and arabinose; however, those under the canopy of native *C. microphylla* shrubs preferred α-ketoglutarate. Although the utilization rate of each carbon group was significantly lower in active sand dunes compared to those with planted or native *C. microphylla* shrubs, soil microbial communities colonizing the active sand dunes relatively prefer consuming amino acids, carboxylic acids, and aromatic acids.

### ***Irrigation with treated wastewater (TWW): a trigger for subsurface soil sodification***

**Guy Levy**, The Agricultural Research Organization, Israel, [vwguy@volcani.agri.gov.il](mailto:vwguy@volcani.agri.gov.il)

Soil productivity in arid and semi-arid regions is fragile. In these climatic regions where shortage in fresh water is frequently experienced, the sustainability of irrigating with marginal water, especially treated wastewater (TWW), and its impact on soil productivity deserve specific attention. Recently, following long-term irrigation with TWW having sodium adsorption ratio (SAR) <5, it has been noted in Israel that subsurface (depth >30 cm) exchangeable sodium percentage (ESP) in orchards is reaching levels of 6-9, being higher than expected based on the SAR-ESP relationship proposed by the U.S. Salinity Laboratory (1954). In an attempt to understand the reasons for these unexpected high ESP levels at the subsurface layers, the relationships between the SAR of the irrigation water, the SAR of the soil solution and the ESP of the studied soils were carefully examined in soil samples taken at different depths (up to 120 cm) from orchards grown in two different soil types that had been irrigated for >10 years with TWW. It emerged that in all sampled sites, except for one, accumulation of adsorbed sodium in the subsurface layers was noted. The obtained ESP levels were higher than those expected when considering the SAR of the TWW used for irrigation. A satisfactory agreement was noted between ESP data and the SAR of the soil solution, signifying that a chemical equilibrium exists between the soil exchange phase and the soil solution. It is postulated that the properties of the irrigation water do not always determine those of the soil solution, especially at sub-surface layers, and that the ESP in those layers is, therefore, not dictated by the cationic composition of the irrigation water. The observed sodification of soil subsurface layers (i.e., the accumulation of ESP at soil to levels >6) may adversely alter soil structure and resultant physical and hydraulic properties. Hence, in semi-arid and arid regions, where soil productivity is a priori low, the sustainability of irrigation with TWW requires a careful examination.

### ***A Decision Support System for Arid Lands Restoration***

**Sarah Milliken**, Benz Kotzen, and Sanjibraj Pandey, University of Greenwich, UK, [S.Milliken@greenwich.ac.uk](mailto:S.Milliken@greenwich.ac.uk)

Restoration planting in arid lands is hampered by the complexity of factors that need to be considered in decision-making, such as hydrology, soils, landform, ecology, climate, microclimate, land use and land management, and other social factors. In this paper we present a Decision Support System for Arid Lands Restoration which integrates land degradation indicators with restoration planting options in order to aid stakeholders in making appropriate choices regarding plant species selection, soil amelioration measures, water supply methods, and sustainable land management practices, taking into account environmental and financial constraints.

The project is a spin-off from COST Action ES1104 “Desert Restoration Hub: Arid Lands Restoration and Combat of Desertification,” which focuses on the dissemination of knowledge about the practical measures that can be used by practitioners, stakeholders, and policy makers to restore degraded drylands and manage their recovery, and facilitates education and innovation in this field (see <http://desertrestorationhub.com> and [http://www.cost.eu/domains\\_actions/essem/Actions/ES1104](http://www.cost.eu/domains_actions/essem/Actions/ES1104)).

Recent research into the effective development of Decision Support Systems (DSS), as measured by the degree to which such systems are subsequently adopted by stakeholders, emphasizes the need for a participatory process that embraces stakeholders throughout the design and development process. Thus a pilot DSS was developed using participatory action research approaches and methods with stakeholders in Kenya, involving requirements analysis, collection of local knowledge on restoration techniques, and a usability survey. Guidelines for sustainable land management practices were generated using Agent Based Modelling.

The ultimate goal is to design a single flexible Decision Support System for Arid Lands Restoration which can be used in different countries by incorporating local data sets. The DSS will be made available free of charge as open-source software.

### ***Microbial secreted exopolysaccharides of induced biological soil crusts in Inner Mongolian desert soils: chemical characteristics and role in affecting water-soil relations***

**Frederico Rossi**, Roberto De Philippis, Department of Agrifood Production and Environmental Sciences, University of Florence, Florence Italy; email: [f.rossi@unifi.it](mailto:f.rossi@unifi.it), [roberto.dephilippis@unifi.it](mailto:roberto.dephilippis@unifi.it)

In nature, Biological Soil Crusts (BSCs) are highly specialized communities constituted by cyanobacteria, green algae, fungi, mosses, lichens and heterotrophic bacteria. They inhabit the first few millimeters of the soil surface in arid and semiarid environments where, due to harsh environmental conditions, the growth of most of the other organisms is restricted. The development of BSCs is widely recognized as beneficial to soil fertility due to their contribution to the stabilization of soils and to the increase in their carbon and moisture content. The induction of BSCs through spray-inoculation of sandy soils with suitable cyanobacteria was shown to be a beneficial and exploitable tool to trigger soil rehabilitation and counteract desertification in a number of experimental sites in Inner Mongolian deserts. An important role in these processes is played by the extracellular polysaccharidic (EPS) matrix embedding microbial cells and soil particles in BSCs. The present study was aimed at investigating the molecular and chemical features of the EPSs and the degradation processes of the polysaccharidic matrix in induced BSCs (IBSCs) of different ages displayed within an investigation area in Hobq Desert (Inner Mongolia, China). The influence of the EPSs in affecting the hydrological behaviour of IBSCs as well as in capturing and maintaining moisture was also investigated.

Two operationally-defined EPS fractions, the colloidal (C-EPS) and the EDTA extractable (tightly bound, TB-EPS) fractions, were analyzed. In BSCs, C-EPSs are loosely bound to cells and sediments while TB-EPSs are tightly bound to the crustal biotic and abiotic constituents of the crusts. C-EPS showed to be mostly constituted by sugar fractions with MW distributed in the range 2000 - 76 kDa and in the range 64 - 0.34 kDa. Conversely, the TB-EPSs showed to be prominently constituted by one fraction having a MW in the range 2000 - 76 kDa. The presence of EPSs in IBSCs also induced a significant decrease in the hydraulic conductivity of IBSCs in comparison with bare sandy soil and contributed to their capability of trapping and retaining humidity.

The results obtained suggest that C-EPSs, which are dispersed in the soil, are more easily degradable by the heterotrophic microflora, while the TB-EPSs, which are characterized by a high MW, play a key role in giving a structural stability to the crusts and in affecting their hydrological behavior.

***Using agro(eco)system services approach to assess tradeoffs of various tilling methods as a tool to improve sustainability and prevent desertification processes in Shikma Park, Israel***

**Hila Sagie**, Open Landscape Institute, Israel, hilasagie23@gmail.com

The Environmental sector in Israel has set itself a goal to experiment with the ecosystem services (ES) approach as a tool to improve decision-making processes, regarding planning and landscape management. In addition to the national ES assessment currently underway, OLI has decided to embark on a pilot study on a regional scale at "Shikma Park" region, located in the semi-arid Negev desert, including a wide range of agricultural fields, mainly unnon-irrigated.

The first step taken was to decide upon which planning and management dilemmas are most crucial to the area. Out of the various issues that were raised, the following was chosen together with stakeholders: "trade-offs of various tilling methods used on the un-irrigated fields of Shikma Park.". The method by which the fields are being tilled and managed affects a large surrounding area. One of the main services affected is soil conservation and prevention of soil erosion. This service is significantly important because soil erosion has been identified in several areas in Israel as a critical problem which may have negative-large scale implications on agrosystems and natural ecosystems and lead to desertification.

Currently there is no agreement among the farmers regarding the optimal tilling method: some adopt conservation tillage (no-tillage combined with or without straw mulch), while others prefer conventional tillage (in this area mainly minimum tillage and plowing).

Working groups, including scientific and governmental experts, economists, and local farmers have been formed for the agro(eco)system services assessment of the different tilling methods. The assessment discovers a complex picture: while soil regulation, water infiltration and carbon sequestration seemed to increase by using conservation tillage, pest control is decreased. Moreover, leaving straw mulch on the field contributes to prevent run-off and erosion but harms the income of the farmer who would normally sell the straw and rent the land for grazing. Whether to allow grazing on the harvested fields creates an additional dilemma: while grazing may have a negative impact on soil conservation and weed control, not allowing grazing may have an economical and cultural impact on the semi-pastoral Bedouin population of the area.

The study and its process suggest that the ES approach is valuable in creating a discourse, among local farmers, policy makers, stakeholders, and experts, which expands the scope beyond provisioning services. It emphasizes the importance of additional services for creating a more sustainable management of agricultural fields, including decreasing desertification processes. Lessons learned from the project may be used to contribute to better integration of this approach in other places in Israel and beyond.

***No adverse effect of stubble grazing on soil quality indicators in dryland wheat agro-ecosystems***

**Ilan Stavi**, Dead Sea and Arava Science Center, Israel, [istavi@yahoo.com](mailto:istavi@yahoo.com)

Rain-fed wheat cropping is widespread across the Middle-Eastern drylands. Livestock husbandry, mainly of small ruminants such as sheep and goats, is also prevalent in this region. A common agro-pastoral practice across the region comprises stubble grazing in previously-harvested wheat croplands. However, several studies have shown that this practice has caused land degradation. Therefore, the objective of this study was to examine the effect of stubble grazing by using several indicators of soil quality and crop yields to compare the continuous wheat croplands of two long-term farming systems: moderate stubble grazing (GR: to a rate of 0.25 Mg ha<sup>-1</sup> dry matter retention) vs. whole stubble retention (NO). The study was implemented in the semi-arid Negev of Israel. Sampling of soil (to 0-10 cm depth) and above-ground biomass of crops was implemented at the peak of the 2013 growing season. Overall, similar values for each of the above-ground biomass, biomass height, and stubble weight were recorded between the two wheat treatments. Also, soil under GR and NO were found to have similar values of wetness depth, gravimetric moisture content, penetration resistance, shear strength, bulk density, and concentrations of total organic carbon and labile organic carbon. However, compared with GR, soil under NO had lower unsaturated hydraulic conductivity. Also, compared with GR, NO had greater carbon liability (L) and carbon liability index (LI), but smaller carbon pool index (CPI) and carbon management index (CMI). Overall, this study suggests that moderate stubble grazing could be considered sustainable in dryland wheat cropping.

## **UK, Israel, and Drylands Symposium**

***Pastoralism and water in Mongolian drylands: the effects of changing climate and the mining industry***

**B. Batbuyan**, Institute of Geography, Ulaanbaatar, Mongolia; [b\\_batbuyan@yahoo.com](mailto:b_batbuyan@yahoo.com)

Mongolia's traditional pastoral animal husbandry system is based on a long history of resource management developed through many generations. Water is a key resource, driving mobility and access to different seasonal grazing pastures particularly. Recent climate changes such as drought, *dzud*, changes to seasonal rains have had a strong effect on herders' animal husbandry management strategies. In addition, recent developments in mining have increased herders' vulnerability. Small-scale gold mining pollutes water and can leave the few rivers in desert areas dry. Dust raised by heavy vehicles transporting minerals (mainly coal) force herders to leave traditional grazing areas which, in some cases have the only deep well for many kilometres. Decreasing water level in hand wells (not deep) increases the heavy concentration of animals around remaining available water points. It also forces herders to transport drinking water over great distances.

Effective community participation in managing man-made rain water storage systems in Sri Lanka  
Ranjith Bandara, Department of Economics, University of Colombo, Sri Lanka; [ranbandara@gmail.com](mailto:ranbandara@gmail.com)

The irrigation works in ancient Sri Lanka, particularly man-made rainwater storage systems, known as tanks, play a major role in sustaining livelihoods in the country's dry zone. These tanks, built by ancient kings and rulers over 3000 years ago, continue to sustain the lives of the people in this area. During the colonial era this system was neglected and communities were forced to abandon them, but in the late 1970s the Mahaveli Development Project revived this rainwater storage system. However recent drought in this area reveals that the system's storage capacity has decreased. The main reason is that management and maintenance has gradually ceased to be a community activity, and shifted into the hands of local state officials. This research uses participatory methodology to assess how local

communities can re-engage with management of the rain water storage system. This experience can be shared in any part of the world to manage similar systems.

***Sustainable maize production and nutrient cycling in a runoff agroforestry system***

**Ilani, T., J. Ephrath, M. Silberbush and P. Berliner**

Agroforestry systems irrigated with runoff events prevalent in arid areas have been implemented successfully in Africa and Asia. Yet, the long term sustainability of these systems depends on nutrients availability, primarily Nitrogen. In a two-year field trial we tested the potential of applying composted leaves of pruned symbiotic N fixing trees in between tree rows, where the intercrop grows. This system resulted in a complementary relation: the maize production increased, while tree growth was not impacted. Implementing the aforementioned may become the preferred solution for reducing the indiscriminate felling of trees and shrubs and at the same time providing firewood and food.

The potential of rainwater harvesting for African agriculture to improve food security and adapt to a changing climate Luuk Fleskens, Associate Professor in Environmental Change Sustainability Research Institute School of Earth & Environment, University of Leeds, Leeds LS2 9JT, UK

In this presentation, preliminary findings from the WAHARA (Water Harvesting for Rainfed Agriculture: investing in dryland agriculture for growth and resilience) project will be presented. Emphasis will be given to three aspects: i) the role of water harvesting in current agricultural systems, ii) critical aspects in using water harvesting as a strategy to cope with climate variability and adapt to climate change, and iii) trade-offs in perceptions of risk and productivity that may impact on the potential to scale up water harvesting more broadly. Results will be based on surveys in 4 distinct regions: Burkina Faso, Ethiopia, Tunisia and Zambia, and continental scale modelling.

***Sustainable resource use in drylands: Sharing UK and Israeli expertise***

**Alan Grainger**, School of Geography, University of Leeds, Leeds LS2 9JT, UK

Scientists in the UK and Israel possess a wide range of knowledge in complementary areas of expertise which can facilitate more sustainable use of drylands in Africa and Asia. Over the last 40 years a wealth of solutions have been proposed and tested, and state-of-the-art scientific knowledge has built on this experience to challenge oversimplistic solutions. This presentation will highlight a number of key thematic areas in which UK and Israel scientists can work together to apply existing knowledge in some areas, and collaborate in research projects to advance state-of-the-art knowledge in other areas so that they can be applicable too. These key areas include: improving the communication of scientific knowledge to policy makers and planners; synthesizing scientific knowledge and non-academic local knowledge to facilitate policy formulation and implementation; expanding the scope of land use science to encompass degradation trends as well as ecosystem area trends, to support planning for land degradation neutrality programmes; and using advanced mathematical methods to convert the Dryland Development Paradigm into an operational suite of models that can be used as the basis for operational planning of sustainable dryland management over large areas.

***Sustainable resource use in dry lands***

**Amit Gross**, Zuckerberg Institute for Water Research, The Jacob Blaustein Institutes for Desert Research, Ben Gurion University of the Negev, Sede Boqer Campus, 84990.

Organic wastes (water, sludge and solid) management in dry remote small rural settlements is challenging and often compromise human health and contaminates the environment. Less conventional decentralized paradigm which utilizes wastes as resources together with minimizing health and environmental harm is suggested. Two research projects aiming at minimization of pollution together with the conversion of wastewater and solid organic wastes in remote desert farms to energy and nutrient sources will be described. The first is a low tech biogas digester which



treats goat manure and dairy wastewater in a farm. The second is a novel hydrothermal treatment. Results suggest high treatment efficiency, in terms of pollution minimization, recovery of nutrients and energy.

### ***On-farm conservation of plant genetic resources for dryland agriculture in Namibia's northern cropping regions***

**G.L. Maggs-Kölling**<sup>1</sup>, N. Black, M. Nalisa, C. Tjazuko, K.N. Iipinga and L.N. Shipingana

<sup>1</sup>*Gobabeb Research and Training Centre, Namibia. gillianm@gobabebtrc.org*

Small-scale farmers manage the genetic diversity of traditional crop varieties and wild crop relatives within dryland cultivation systems in Namibia. They face escalating threats, which may compromise this diversity, anticipated to be further compounded by global change. An assessment of on-farm practices was conducted in northern Namibia. Farmers have developed effective strategies to conserve germplasm, and developed practices to adapt to climate variability. A support intervention identified was access to timely, accurate weather forecasting. Limited understanding of traditional systems and risk management may lead to inappropriate advice through extension efforts. Targeted scientific endeavour will marry sustainable traditional systems and development for small-scale farmers.

### ***Augmentation and enhance water use efficiency through farm pond and micro irrigation in rainfed area of Kashmir valley***

**Rohitashw Kumar**, Associate Professor & Head, Division of Agricultural Engineering, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar (J&K)-191121, India; vijay196129@gmail.com

- Present scenario of water resources in Himalayan region
- Climate change and water resources
- Planning for future response to water resources and climate change
- Strategy for augmentation of water resources for dryland area.
- Augmentation of water resources using low cost water harvesting structures.
- Design of different water conservation structures for hilly rainfed/dryland area using different lining materials
- Utilization of water through design of high irrigation efficiency methods like micro irrigation system in different crops and increase water use efficiency from 40-60%
- It has been observed that, water saving from 30-60% and yield increase from 20% to 80% in different crops
- Climate change and its impact on agricultural productivity
- Sustainable management practices for dryland area

### ***Natural Resource Management in Dryland of Kachchh - Pathways Towards Sustainability under Desertification and Climate Change***

**V. Vijaya Kumar**, Additional Director, Gujarat Institute of Desert Ecology, Bhuj- 370 001, Kachchh, Gujarat, India; vijay196129@gmail.com

The Kachchh district (45,652 km<sup>2</sup>) located in the north-west of Gujarat state, India entirely falls under drylands. The district harbours Banni grasslands (2617 km<sup>2</sup>), Ranns of Kachchh (unique saline desert, 23,000 km<sup>2</sup>) and 405 km long coastline with mangroves. Kachchh is known for its uncertainty and the phenomenon of desertification and climate change adds to existing woes and affects two major livelihood areas; agriculture and livestock.

Three major programmes have been undertaken to address the issues;

Banni Grassland restoration to enhance livestock based sustenance.  
 Watershed programmes to improve agriculture, land quality, surface and ground water.  
 Reclamation of Greater Rann – attempt to enhance the productivity and its services.  
 The presentation covers the success stories and lessons learned from these three projects. Also, a brief on climate change issues and its coping mechanism.

***A review of factors affecting the development of smallholder irrigation and rangeland grazing Schemes in Semi-Arid Areas of the North-West Province in South Africa***

**Simeon A. Materechera**, Faculty of Agriculture, Science & Technology, North-West University, (Mafikeng Campus), South Africa. albert.materechera@nwu.ac.za

The North West Province of South Africa is largely semi-arid and demands for water are exacerbated by climate change. Government has in the past rendered support to irrigation and rangeland conservation schemes but studies have revealed that their performance was well below potential. Degradation of rangelands due to overgrazing is evidenced by occurrence of soil erosion, bush encroachment, poor rangeland condition and loss of bio-diversity. Most of the irrigation schemes have collapsed while those in operation are fraught with difficulties. This paper examines the social, human, economic and technical aspects of these schemes and draws some lessons for the future

***Human amplification of climate hazards: 2010 floods in Pakistan***

**Henri Rueff**, School of Geography and the Environment, Oxford University, UK

The Indus River plain is a vast expanse of fertile land covering about 200,000 square miles. Climate change impacts overall water availability and agriculture yields in this system, but also impacts the different land holders in different manners. This study identifies how intrinsic anthropogenic factors amplify climate events and how variable climate scenarios will impact the economy and food security in the region. This presentation reviews the 2010 floods in Pakistan and identifies human factors that contributed to the severity of the event. It identifies the variation in impacts in mountain valleys and flood plains and finally the political dimensions of flood disasters.

***Agro-ecosystems under stress: functioning and management***

**Ilan Stavi**, Dead Sea & Arava Science Center, Ketura 88840, Israel

Increasing natural and anthropogenic pressures on agro-ecosystems have accelerated risks of land degradation and ecosystem services depletion. In drylands, these risks have further exacerbated water shortage under a range of land-uses, including croplands, rangelands, and forestry lands. Case studies of recent research projects regarding each of these three land-uses from the semi-arid Israeli Negev will be presented in order to demonstrate the competition among different needs, and highlight the importance in scientific advancements, as well as the urgency in environmentally-based policy making.

***Water scarcity and agricultural challenges in Chinese drylands***

**Troy Sternberg**, School of Geography and the Environment, Oxford University, UK

As Asia's largest dryland country, water scarcity is a major threat to China's sustainable future. The issue is particularly acute for cultivation as limited arable land, urbanisation and development drives agriculture to the dry northern plains and arid western regions. In rural landscapes the sustainability of farming and herding are challenged

by manipulated water systems, government policy favouring mining and urban users, dryland environments and climate variability that exist within a system of overweening bureaucratic control. Resulting processes contribute to land degradation, marginal livelihoods and inadequate environmental engagement as land use decisions are based on short-term policy and economic criteria. Balancing strengths, including the state's ability to take action, with weaknesses, such as environmental exploitation and over-regulation, could improve sustainability across Chinese drylands.

### ***Water and climate change adaptation in rural Africa***

**Katharine Vincent**, Kulima Integrated Development Solutions (Pty) Ltd, Hilton, South Africa.  
katharine@kulima.com

This presentation examines three examples of potentially unsustainable water use in rural Africa. South Africa's Constitution includes rights to water, which tends to be prioritised (particularly in former homeland areas) over other conflicting policies that encourage resource conservation. In Cameroon some adaptation interventions focusing on improved crop varieties have overlooked changing water availability. In Zambia, traditional water resource management is still intact but less effective due to inadequate communication of predicted seasonal conditions. In all three circumstances vulnerability to climate change may be (inadvertently) increased. The presentation concludes with recommendations for ensuring sustainable adaptation to changing water availability under climate change.

### ***Rural Water Development: Should it be an essential course for graduate students?***

**Noam Weisbrod**, Zuckerberg Institute for Water Research, The Jacob Blaustein Institutes for Desert Research, Ben Gurion University of the Negev, Sede Boqer Campus, 84990.

A course on International Rural Water Development has been conducted for the last five years at Ben-Gurion University of the Negev (BGU). The water technology experience, gained through years of practical work and research by our experts, is transferred, via direct interaction, from BGU scientists and students and to colleagues in NGOs and local communities in rural Africa.

The benefits of such a course are: First, it exposes students to water issues in rural communities. Second, the course proposes to link the strengths of the academia with water management experience in rural areas of developing countries. Finally, the students are taking part (and working hard) to implement solutions to water problems in rural areas.

## **UNCCD-SPI: Land Based Adaptation to Climate Change**

### ***The Economics of Land Degradation (ELD) Initiative - Integrating the economics of land degradation into policy making***

**Tobias Gerhartsreiter**; Germany

The Economics of Land Degradation (ELD) Initiative as a partner of the UNCCD contributes to the shared goal of promoting a more sustainable land management and a re-framed understanding of the importance of the natural capital represented in our soils. On this background, the ELD undertakes has developed a framework of approaches to identify not only the cost of land degradation but also serves to create a reliable foundation to assess the economic

benefits from a soundly managed land. Based on this analytical foundation, the ELD Initiative is now beyond scientific analysis: In cooperation with the Soil Leadership Academy, ELD is now engaging a holistic science-policy dialogue in Central Asia to facilitate the development of training courses for political decision makers. Through a partnership with GIZ and its bilateral cooperation, scientific research is now coupled with multi-level stakeholder consultations and training to facilitate the development of needed policies and their uptake. A Massive Open Online Course (MOOC) was successfully conducted during 2014, which did not only address >1600 participants worldwide from the private and policy sector and provided them with hands-on knowledge on the assessment methods, but has created a lively discussion and knowledge-sharing platform.

### ***Monitoring desertification after the AGTE***

**Alan Grainger** (SPI) School of Geography, University of Leeds, Leeds LS2 9JT, UK

Establishing an effective method for monitoring desertification globally is essential for monitoring progress in achieving a Land Degradation Neutral World. The UN Convention to Combat Desertification (UNCCD) has been attempting to identify a feasible set of indicators to monitor desertification and the impacts on this of UNCCD activities ever since the Convention came into force in 1996. For example, four expert panels were convened between 1996 and 1998 alone. The latest developments relate to a set of eleven "impact indicators" that were agreed in provisional form by the Ninth Conference of the Parties in 2009, based on the recommendations of expert panels convened in 2010. Following the results of subsequent pilot studies of these indicators, the Tenth Conference of the Parties in 2011 established an Ad Hoc Advisory Group of Technical Experts (AGTE) to refine the set of indicators further. The AGTE began work in 2012, and while it was given an 18 month mandate it actually submitted its recommendations to the Eleventh Conference of the Parties in 2013. Its Final Report, which justifies these recommendations in detail, is currently being completed. This paper will assess the contribution made by the AGTE to desertification monitoring generally, by critically evaluating the feasibility of the refined set of indicators recommended by the AGTE; assessing the advance that the refined set represents over previous sets; examining the robustness of the AGTE's analysis of previous versions and of earlier sets of desertification indicators; and comparing the work of the AGTE to parallel activities which are designed to produce a new World Atlas of Desertification.

### ***The science of making land adapted to climate change – an attempted assessment***

**German Kust** and Olga Andreeva, Moscow Lomonosov State University, Moscow, Russia; gkust@yandex.com, andreevala@yandex.com

The attempt of incorporating sustainable land management (SLM) paradigm in the climate change (CC) adaptation discourse raises several questions: Are there appropriate terminology and methodology? Are the dominating concepts, hypotheses, visions, statements and imperatives related to this issue scientifically justified? What are the fundamental interrelations between desertification/land degradation (DLD), CC, disasters, and their risks?

In this study some conclusions are derived from using the land (sensu UNCCD)/ecosystem (sensu CBD)- based climate change adaptation (LbA and EbA, respectively) approach for molding the SLM paradigm in the context of the CC.

### ***Avoiding land degradation and restoring degraded land: A comparative analysis of Asia and Africa (Sri Lanka & Uganda)***

**David Mutekanga**, Uganda; drmbaleke@yahoo.co.uk

Available data on soil erosion in Sri Lanka and in Uganda is that soil erosion rates are very high on annual and plantation croplands especially in areas with low ground cover. This paper highlights the major causes of ground cover loss in both these countries and identifies that the causes are similar in many ways. The paper also shows that

when the ground cover is maintained along with observing soil conservation methods then the amount of erosion could be minimal in both developing countries.

While the traditional technologies and methods used to control land degradations in both countries are different, they are actually comparable when it comes to the effect they have in minimizing the degradation, their efficiency, costs and ease of application.

The paper also highlights the new methods that have been introduced in both these countries and they are divided into three categories: mechanical, biological and agronomic measures. These three methods are being used concurrently with the local traditional methods in both these countries with very positive and sustainable results in a number of instances.

The paper concludes with major recommendations of the way forward in reducing land degradation in both these countries at relatively low cost.

### ***Global assessment of the cost of land degradation & strategies for achieving land degradation neutral world***

**Ephraim Nkonya**, Alisher Mirzabaev, Weston Anderson, Ho-Young Kwona, and Edward Katoa; International Food Policy Institute; University of Bonn.; e.nkonya@cgiar.org

Land degradation – defined by the millennium ecosystem assessment report as the long-term loss of ecosystems services – is a global problem, negatively affecting the livelihoods and food security of billions of people. Intensifying efforts, mobilizing more investments and strengthening the policy commitment for addressing land degradation at the global level needs to be supported by a careful evaluation of the costs and benefits of action versus cost of inaction against land degradation. Consistent with the definition of land degradation, we use total economic value (TEV) approach to determine the cost of land degradation. Within this analysis, remote sensing data and global statistics databases are employed to determine the cost of land degradation. Our results show that the annual cost of land degradation due to only land use and land cover change (LUCC) dynamics is about US\$ 2.2 trillion or about 2% of the global GDP of US\$108 trillion in 2007. The loss is especially high in sub-Saharan Africa, where land degradation is most severe. However, the local tangible losses (mainly provisioning services) account for only 38% of the total cost of land degradation and the rest of the cost is due to loss of global benefits such as carbon sequestration, biodiversity, and genetic information. This implies the global community bears the largest cost of land degradation. This suggests that efforts to address land degradation should be done bearing in mind that the global community incurs larger losses than the local communities experiencing land degradation. The results also show that the benefit of taking action against land degradation through sustainable land management measures is much greater than costs of inaction. Investments into addressing land degradation are likely to provide with high rates of economic, environmental and social returns.

### ***The UNCCD Science-Policy Interface (SPI) and its efforts to explore the sustainable land management nexus among the Rio Conventions***

**Barron J. Orr**, PhD; University of Alicante, Faculty of Science; University of Arizona, College of Agriculture; UNCCD Science-Policy Interface (SPI)

At its 11th meeting in Windhoek/Namibia, in September 2013, the United Nations Convention to Combat Desertification (UNCCD) Conference of the Parties (COP) decided to establish a Science-Policy Interface (SPI) (decision 23/COP.11). The goal of the SPI is to facilitate a two-way dialogue between scientists and policy makers in order to ensure the delivery of policy-relevant information, knowledge and advice on desertification/land degradation and drought (DLDD). The SPI establish several initial objectives, the first of which, to be elaborated on in the UNCCD-SPI session is to bring to the other Rio conventions (climate change and biodiversity) the scientific evidence for the contribution of sustainable land use and management to climate change adaptation/mitigation and to safeguarding biodiversity and ecosystem services.

### ***Time for Paradigm Shift in How We Transfer Knowledge? Making the Case for Translational Science and Public Engagement***

**Barron J. Orr**, Ph.D; School of Natural Resource and the Environment, University of Arizona; Professor and Marie Curie Fellow, Department of Ecology, University of Alicante

By any measure, our efforts to protect and restore the environment have failed to keep pace with environmental change, despite extraordinary advances in land degradation science and practice. Clearly there is a problem in knowledge transfer, frequently blamed on limited public awareness, misunderstanding or even apathy. The irony is that the same people who have contributed to knowledge advances – scientists and practitioners – are unwittingly contributing to ineffective knowledge transfer, which in turn limits the impact of interventions. First we will explore why the commonly proposed solutions of “better science communication” and “raising awareness” are often ineffective and almost always insufficient. Then the case for an engagement-based approach that has been demonstrated to have impact will be made.

### ***A method for integrated assessment of vulnerability to drought***

**Rajendra Prasad Pandey**; National Institute of Hydrology, Roorkee-247667, India; rppandey@gmail.com

A methodology for assessment of drought vulnerability at spatial and temporal scales has been devised using physiographic, climatic, and hydrologic factors. The physiographic factors include topographic characteristics, land use, soil type, soil depth, population density and proximity to river reach. The climatic and hydrologic factors are rainfall, water availability and soil moisture which vary with time and space. Spatial information on above factors is categorized in to various sub classes and maps are prepared in using Geographic Information system (GIS). Different layers of above factors have been integrated on 100 m X 100 m grid scale in spatial domain using a weighing scheme. Thus, values of weights of various factors for each grid have been summed to depict integrated vulnerability to drought.

### ***The UNCCD, what is it all about?***

**Sergio Zelaya**; Secretariat of the United Nations Convention to Combat Desertification (UNCCD)

Desertification, climate change and biodiversity loss have been identified as the greatest challenges to sustainable development since Rio 1992, when the Rio Conventions were agreed upon.

The UNCCD is the only international agreement on sustainable development that addresses sustainable land management. It is a legally binding agreement that provides attention to issues related with land degradation and desertification, with a special focus on bottom-up approaches and international cooperation.

The convention is mandated to address a crucial global problem-issue that is at the heart of development in most developing countries: addressing land and soil dynamics for combatting land degradation and desertification through – among others - proven sustainable land management approaches. As such, it complements the other Rio Conventions in relation to land-based ecosystems (adaptation / mitigation to climate change and conservation of their biodiversity) and also politically.

Country Parties to the UNCCD guide the implementation of the convention through a decision-making process. The convention bodies (Secretariat, Global Mechanism, Committee on Science and Technology) are part of the framework of support to Parties in carrying out the implementation of the convention at the national level.

In 2007, the parties adopted a ten-year strategy (2008-2018) designed to sharpen the focus of UNCCD implementation and the work of each of the Convention bodies. Four strategic objectives were agreed upon, for improving both the ecosystems of affected areas and the livelihoods of people living in those areas. In turn, improvements to populations and ecosystems would generate global benefits. The final strategic objective refers to effective partnerships for resource mobilization.

The convention provides a forum for global policy-oriented decision-making and target-setting on land issues. It complements the work of specialized agencies and organisations from the UN (such as FAO, IFAD...) and other partners, focusing on specific aspects of agricultural and rural development, water, forestry, governance and other social aspects (poverty, migration for example).

The secretariat of the Convention supports its implementation by servicing the meetings of the COP and its subsidiary bodies and by carrying out global level activities to drive the implementation of the Convention, including awareness-raising and advocacy, ensuring linkages with relevant international stakeholder and processes, for science-based interface with decision-making; and the promotion of partnerships.

There is a value added that the UNCCD fosters to existing science and research when it aims at bringing together scientists for information exchange on approaches and practices related with land and soil issues. The strategy is to use existing and globally accepted baselines and standards concerning desertification / land degradation and drought that can lead to improved levels of data comparability among countries and regions, and to create stronger scientific evidence to support decision-making.

Fostering acting together on ecosystem restoration through SLM, moreover in the current scenario of increasing population pressure, climate change and biodiversity loss, is one key strategic approach of the convention. Land degradation and the impacts of extreme weather events will worsen if policies for restoring degraded ecosystems, bringing back the land's productivity potential to effectively contribute to food security, human security, reduce poverty and conserve biodiversity values are not set in place. The UNCCD is leading in the promotion of SDGs that refer to land and soils, such as the "Land Degradation Neutrality" concept that is currently included under proposed target 15 of the SDGs.

### ***An approach to the identification of indicators for land-based adaptation to climate change***

**Sergio A. Zelaya** & Victor Castillo; Secretariat of the United Nations Convention to Combat Desertification (UNCCD)

The scientific and technical process at the United Nations Convention to Combat Desertification (UNCCD) has developed options for monitoring and assessment (M&E) and the associated land-based indicators. Reporting on these processes with the indicators proposed can boost development of policy options to analyse and to counter unsustainable land management trends.

Many global policy instruments focused on climate change adaptation solutions deliver synergistic co-benefits that would further the long-term objectives of the Rio Conventions. Of particular interest are the land-based approaches can help communities and ecosystems adapt to the impacts of climate change by improving land conditions and productivity, and reducing biodiversity loss, as well as providing co-benefits on greenhouse gas emissions reduction; this is the collective core missions of the Rio Conventions.

One way to foster this approach is through joint action of the Rio conventions (CBD, UNFCCC and UNCCD) on the value and effectiveness of implementing sustainable land-based solutions when addressing climate change adaptation that could be easily reported upon by Parties of the three Conventions, and consequently monitored, evaluated and communicated.

Operationally, this integration of efforts aims at the development of agreed indicator(s) for reporting on the collective issue of land-based adaptation, to be used by the parties of the three Rio conventions when reporting on their actions on Climate Change (CC) adaptation at the national level.

Moreover, monitoring progress towards land-based actions can contribute to effective implementation of integrated frameworks for CC adaptation and to more consistency when reporting progress towards common objectives and outcomes. However, identifying monitoring and evaluation (M&E) frameworks, including indicators for land-based adaptation is a major challenge for the global community.

The integration of common socio-economic indicators on land-based assessment programmes is a *sine qua non* condition for effective decision making when reporting on land issues and adaptation to climate change. The role of the scientific community is to develop further these indicators without delay, and promoting and interface or dialogue among scientists and decision-makers, not only at the global level but also local/nationally.

The proposed recommended indicators regarding Land-based Adaptation are based on a monitoring framework, and proper methodologies. Therefore the three-step approach is:

- (1) Define the steps for monitoring and evaluating adaptation policy and practice, in order to encourage adaptation action and national assessment;

- (2) Propose the development of a set of recommendations with practical methodologies, tools and options for common indicators or a framework for national reporting on land-based adaptation policies and practices.
- (3) Propose and adopt the biophysical indicators for reporting on land-based adaptation proposed by the UNCCD, within a monitoring and evaluation framework:
  - Land productivity dynamics
  - Land cover change as an outcome of land use change; and
  - Trends in carbon stocks above and below ground.

For this to work, it needs further discussion and consideration at international meetings COPs, towards a final decision in the context of UNFCCC COP 21 in Paris in 2015.

## Water Management Challenges in the Drylands

### *A tale of two rivers: Pathways for improving water management in the Jordan and Colorado River basins*

**Assaf Chen**; Ben-Gurion University, Israel; [assafchen@gmail.com](mailto:assafchen@gmail.com)

This paper, considers two river systems that have been subject to significant development during the last 60 years: the Jordan River in the Middle East and the Colorado River in the western United States. Both, play major roles in serving the demands of growing populations. Climate change models predict both semi-arid to arid regions to become hotter and/or drier in the future. The Jordan River basin, shared by five nations, is already experiencing a critical level of environmental damage. Its lower stretch is practically a sewage canal, with less than 10% of its natural base-flow. Due to its unique historical, religious and environmental role, restoration efforts have gained momentum and wide public support. In the Colorado River Basin, water law is characterized by the "Law of the River" and water use is managed through regional allocation constraints. The Colorado River, shared by seven U.S. states and Mexico, is highly managed and over-allocated. Shortage declarations have serious implications for low priority users, with the Central Arizona Project being among the lowest. This makes large population centers and agricultural users vulnerable to curtailment of deliveries. We argue, that there are common factors with respect to the policy and management options of these two basins that may provide insights into the similarities and divergences of their respective future pathways. These factors are: regional water supply and demand pressures, water governance, transboundary issues and demand for environmental flows. With a particular focus on the Israeli and Arizona portions of these respective river basins, we address: synergies and tradeoffs between groundwater and surface water usage, sectoral allocation strategies, public vs. private water ownership and legality, transboundary sharing, technical options for addressing growing regional water scarcity, and economic considerations. Difficult and bold decisions are required in both regions.

### *Transboundary aquifer assessment at the United States-Mexico border*

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This presentation will focus on the successful United States (US)-Mexico (MX) effort that has produced, the first-of-its-kind set of, binational aquifer assessment reports for the transboundary Santa Cruz River aquifer and the San Pedro River aquifer. These border areas of Arizona (US) and Sonora (MX) rely on groundwater to meet their municipal, industrial (including mining) and ranching/farming needs. Through a cooperative framework officially adopted in 2009 by the US-MX International Boundary and Water Commission (IBWC), a partnership of agency and university experts has been working on assembling the scientific information and harmonizing maps for the bilingual reports; which are expected to be finalized in the second half of 2014. The effort represents an unprecedented level of cooperation related to aquifers, as there is no international groundwater treaty in place. As lead Principal Investigator for the US academic team and participant in the legislative process leading up to the US authorization of the program, I will speak to the challenges and successes of the international collaboration to date, the reports themselves, and next



steps. I will also relate, the aquifer assessment effort to a major transboundary collaboration regarding the Colorado River and pulse flows designed to reach the Colorado River Delta. A key takeaway message, is, that it is important to have a binational organization to facilitate and establish the framework for transboundary water assessments, including binational approval of the final reports.

***Water resource management, ecosystem services, land use changes in the transboundary Ili river basin***

**Niels Thevs;** University of Greifswald, Germany; thevs@uni-greifswald.de

The most productive and diverse natural ecosystems, as well as, food and fiber production and population in the drylands of Central Asia, are concentrated along the rivers (e.g. Amu Darya, Syr Darya, Chu, Tarim, and Ili). Therefore, land users and natural ecosystems compete for water. Often, income is generated upstream at the cost of land degradation downstream, (e.g. the desiccation of the Aral Sea and ecosystem degradation in the downstream and delta regions of the Amu Darya and Syr Darya). Today, Lake Balkhash in Kazakhstan, has become the largest lake of Central Asia; with an area of 18,000 km<sup>2</sup>. The Ili Delta, with an area of 8000 km<sup>2</sup>, is the largest wetland complex of Central Asia; which still receives water permanently. Thus, it harbours rather non-degraded riparian natural ecosystems. The Ili River, which contributes 70% of all water draining into Lake Balkhash, is a transboundary river, as its headwaters are located in China (Xinjiang). The transboundary governance structure related to the Ili river basin are weak. The reality of water resource management and land use changes, from the 1970s to the present, with implications on the wetland complex of the Ili Delta and ecosystem services, (i.e. biomass and fodder production, regulating the water cycle, carbon storage, recreation, habitat for fish), have shown to be a basis for future projects. The irrigated area in the Kazakh part of the Ili river basin, was halved in the course of the collapse of the Soviet Union, while in the Chinese part, there is a steady increase of irrigated land. The grazing pressure was considerably reduced in the course of the collapse of the Soviet Union, so that wetlands recovered. If the current trend of reclaiming land along the Ili River prevails, it is expected that the wetland area, with its associated ecosystem services, will shrink.

***Monitoring impacts of a critical economic sector on a critical resource: minerals and water resources in the central Namib***

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Draining into the moist highlands of Namibia, before cutting through the hyper-arid Namib Desert and a large protected area, the ephemeral Swakop and Kuiseb Rivers contain dense forests of large trees that are supported by groundwater in the sandy aquifers of the riverbeds. These “linear oases” provide resources that are critical to the survival of other organisms and provide food and water for humans. The same region, is also home to the “Uranium Province”, a part of the central Namib where uranium-mineralized zones are concentrated in a relatively small area. Although the right to an intact environment is enshrined in the constitution, and with >20% of the country under some form of protection, Namibia, as a hyper-arid to arid developing country and a small economy, cannot afford to exclude mining – a critical economic activity – from its protected areas. It has to find a way to allow these opposing land-uses to coexist. A dramatic increase in uranium prices in 2007, led to a rush for exploration licenses and a subsequent Strategic Environmental Assessment (SEA) study that looked at the most likely cumulative impacts assuming different numbers of mines being developed simultaneously. The SEA identified water as a key driver and a critical resource, and defined a number of mechanisms through which this resource could potentially be impacted as a result of mining. Because of the ephemeral rivers’ central role in maintaining biodiversity, the potential effect of groundwater abstraction on riparian ecosystems was considered to be important enough to be studied and monitored. For this reason, a component of the SEA’s associated Strategic Environmental Management Plan for the Uranium Province (the SEMP) aims to understand both the natural dynamics of groundwater and the effects of natural and anthropogenic changes in groundwater levels on the important riverine ecosystems. We, therefore, launched a baseline study of the health of riverine vegetation, (principally large trees), and established protocols for monitoring tree health as a function of groundwater levels. Here, we report on the baseline patterns and highlight some important background dynamics that will make it difficult – but not impossible – to identify the signal of over-abstraction within

the noise of a highly variable natural environment. This monitoring program should be continued as part of the integrated SEMP; with results being reported to the public, industry and the government, and with an aim to mitigate any future impacts on the riverine ecosystems.

## **Women and Economic Changes in Rural Arid Regions**

### ***Transforming Economies and Roles: Bedouin Women Recreate Economic Change***

Sarab Abu-Rabia and Avigail Morris, Dead Sea and Arava Science Center, Israel; sarab@bgu.ac.il

As subsistence economies yield to cash economies, some women are losing their productive roles within the family. Such economic systems are frequently analyzed linearly on a substantivist to formalist spectrum. We examined women's informal economic activity in Israel's unrecognized Bedouin villages (communities lacking educational opportunities, employment prospects, and basic infrastructure) to show how this unique setting has motivated Bedouin women to develop alternative income-generating activities within traditional Bedouin social structure. Their productive roles, we argue, are pertinent in processes of economic change, creating a viable synthesis of modernization and existing culture in a way that safeguards their socio-cultural institutions.

### ***Rural women energy security project as a social entrepreneur approach to checking desertification in rural- arid regions***

**Priscilla Achakpa**, Nigeria; pmachakpa@gmail.com

More than three billion people around the world still burn wood, coal and other traditional fuels inside their homes. The use of solid and fossil fuels in cooking, according to World Health Organization (WHO), kills over 98,000 Nigerian women annually; and this figure represents about 10% of the annual global figures. The Rural Women Energy Security (RUWES) project drives from a need to save lives, save the earth and improve the economy. It is domiciled under the Renewable Energy Programme (REP) of the Federal Ministry of Environment and driven by rural women through their community-based associations, Non-governmental Organizations, Faith Based Organizations and financed by micro finance banks. The project targets wealth creation by improving the value chain of the under-served rural women who are usually off grid, without access to energy, who depend on fuelwood for cooking and have the highest incidence of health related issues from harmful energy practices. This paper shares practical experiences and strategies of how rural women in Nigeria have used a multifaceted approach to improving their well-being, alleviate poverty and grant access to financial independence for maximum impacts in programmes of combating desertification and thus, recommends the strategies to other countries depending on their peculiarities and situation.

### ***Bedouin Women at the Forefront of Development through Innovative Approaches: Sidreh's Desert Gardens***

**Heidi Paredes**, Sidreh, Israel; paredes.heidi@gmail.com

Established in 1998, Sidreh is a non-profit organization, whose mission is to support the Arab-Bedouin woman in the Negev in her pursuit of the full realization of herself and her rights as well as of those of her community. One of our pillars of work is Economic Development and one of our approaches to reach economic development and resilience is by maximizing the use of available resources, including water and land. This is how we started the Desert Gardens' Project.

Sidreh started a pilot project in October 2013 in two villages: Um Batin and Lakiya. Our assumption was that local, women-led small-scale gardens would improve the health and economic situation of families in the Negev while contributing to community building and self-sustainability. With the aim of testing our assumption, we built 3 different plots to cultivate vegetables and fruits for family consumption. Each garden tested different permaculture, aquaculture and hydroponic methods, in accordance with availability of natural resources, and intended scale and purpose. Through this project we reached more than 40-60 direct beneficiaries (including children, women and men).

We were able to mobilize various resources to unprecedented levels (including financial, volunteers, and local skills). The project was conducted in collaboration with the international organization Byspokes, and Marsha Zibalese-Crawford, professor at Temple University in Philadelphia, US.

The preliminary evaluation of the Desert Garden Pilot confirms that these gardens can play a significant role in enhancing the physical and emotional well being necessary to build healthy and socially sustainable communities. Through the pilot project we could see that community improvements resulting from gardening efforts range from knowledge and skill enhancement to behavioral and systems change. From October 2014 until September 2016, Sidreh will scale up the Desert Gardens project in 8 villages in the Negev (which ones). We aim to reach 4,000 - 5,600 children, 200-250 parents, 100 teachers, 10-20 experts and business people. The specific aim is to reduce rates of malnutrition and enhance physical and emotional well-being among young Bedouin children growing up in unhealthy physical environments in the Negev.