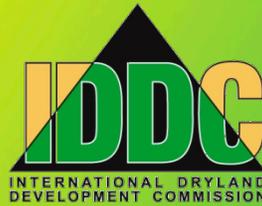


**Twelfth International Dryland Development Conference  
“Sustainable Development of Drylands in the Post 2015 World”**

**21-24 August 2016, Alexandria, Egypt**

**ABSTRACTS**



**International Dryland Development Commission**

**August 2016**

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**International Dryland Development Commission**

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## International Dryland Development Commission

The International Dryland Development Commission (IDDC) is an autonomous nongovernmental nonprofit organization established in 1987 by the individuals and institutions interested in and concerned about the sustainable development of dry areas. It is promoting all aspects of dryland studies by fostering cooperation, collaboration and networking between various international, regional and national organizations. One of the important *modus operandi* of the networking of IDDC has been to hold a major scientific conference every two to three years to provide opportunity to participants from around the world to exchange research results and experiences in dryland development and combating desertification. In pursuance of this objective the IDDC has organized in the past following 11 international conferences in countries that have large dryland areas:

1. First International Conference on Desert Development: *Application of Science and Technology for Desert Development*, Cairo, Egypt, 1978.
2. Second International Conference on Desert Development: *Desert Development Systems – Technologies for Desert Agriculture, Energy and Communities*, Cairo, Egypt, 1987.
3. Third International Conference on Desert Development, Beijing, China, 1990
4. Fourth International Conference on Desert Development: *Sustainable Development for our Common Future*, Mexico City, Mexico, 1993.
5. Fifth International Conference on Desert Development: *Desert Development -The Endless Frontier*, Lubbock, Texas, 1996.
6. Sixth International Dryland Development Conference: *Desert Development: Challenges in the New Millennium*, Cairo, Egypt, 1999.
7. Seventh International Dryland Development Conference: *Sustainable Development and Management of Drylands in the 21st Century*, Tehran, Iran, 2003.
8. Eighth International Dryland Development Conference: *Human and Nature working together for Sustainable Development of Drylands*, Beijing, China, 2006.
9. Ninth International Conference on Dryland Development: *Sustainable Development in the Drylands – Meeting the Challenge of Global Climate Change*, Bibliotheca Alexandrina, Alexandria, Egypt, 2008.
10. Tenth International Conference on Development of Drylands - *Meeting the Challenge of Sustainable Development in Drylands under Changing Climate - Moving from Global to Local*, Cairo, Egypt, 2010
11. Eleventh International Dryland Development Conference - *Global Climate Change and its Impact on Food & Energy Security in the Drylands*, Beijing, China, 2013.

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# Plenary Presentations

## Plenary Session 1

### **1. Achieving Sustainable Development Goals (SDG) in the dry areas - a myth or a real possibility**

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The World, in 2015, has witnessed three major agreements related to the global sustainable development: ‘Sustainable Development Goals’ (SDG’s), the ‘Paris Agreement’ to coordinate efforts to tackle climate change, and the ‘Sendai Framework for Disaster Risk Reduction’. They would greatly impact sustainable development globally in general and in the dry areas of developing countries in particular. The price of not implementing the three agreements or any complacency in developing action plans - globally, regionally and locally would be catastrophic. Climate change, with an increase in temperature and the rise in sea water level, will have an adverse impact on the livelihood of seven billions people that inhabit our globe now, and the situation will worsen if the projected rise of the population to 9 billion in 2050 were to come true. This will greatly disturb the coping capacity of our planet, and lead to severe ecological disaster. The approach to integrated natural resources management has to be customized to different ecosystems to meet the needs of communities that depend on them. Such approach would require developing intensive knowledge and understanding of the coping mechanisms to deal with drought risk, managing and restoring ecological functions, sustainably harvesting of biodiversity, diversifying production system and livelihoods, and this technological understanding has to be shared globally, regionally and nationally. Supporting policies and institutional options would be needed. These are the building blocks for sustainable development. The landmark agreements of Paris and Sendai are only partially legally binding, and thus much will be left for voluntary action. A massive and dynamic campaign is, therefore, necessary to ensure that an internationally binding legal framework is put in place. Although there was a pledge made in Cancun in the past to establish a technology box and a fund to support the developing countries in improving their coping and adaptive capacities and minimizing their vulnerability to climate change, this has not been effectively fulfilled. The commitment of making hundred billion dollars available per year, up to 2020, to developing countries to adapt to climate change is yet to be met. Nationally Determined Contributions (NDC) that each country has to express voluntarily, reflect the pillars of implementation. These are: (a) Political will and effective governance, (b) Long term mitigation strategies, (c) Integrated adaptation planning and implementation programs, (d) Finance framework to cope with climate change, and (e) New institutions, credits, and legislation. Optimization and enhancing synergies between the international, regional, and national research systems is highly

required. Knowledge gap related to the assessment of the impact of climate change on local and regional levels is yet to be assessed through global efforts and partnership. The developed countries have to realize that all their contributions (knowledge and finance) will be an investment for secured livelihood of their peoples. The projected number of out migration because of possible climate change (environmental refugees) could reach two hundred million by 2050. This element, one of many negative implications of climate change would justify the need for such a support. There is a need for a strong alliance for sustaining our planet and spreading peace and prosperity in the world. This will require a shift of consciousness on the part of both, those that ‘have’ and those that ‘have not’, and a new deep understanding of oneness of humanity.

**Keywords:** Climate change impacts, SDGs, Paris Agreement of UNFCCC, Sendai Framework for Disaster Risk Reduction, Sustainable resource management, Bridging technological knowledge gap, Capacity building, Political will

## **2. Strengthening resilience and adaptive capacity of NENA dryland agricultural systems to climate change and related shocks: FAO contribution**

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Drylands ecosystems, being characterized by conditions where mean annual precipitation is less than two thirds of potential evapotranspiration, have significant gaps in agricultural productivity and environmental-services. With expected rising in temperature largely above 3°C by century’s end, runoff decrease by over 40%, and the alarming trend of more frequent, intense and prolonged droughts of recent decades, NENA drylands will be among the world’s most vulnerable ecosystems to climate change and related shocks. There are various adaptation measures that can increase the resilience of these dryland ecosystems and livelihood to the negative impact of climate change, drought and land degradation. Some are based on natural resource management, combining land conservation and productivity enhancement practices, including conservation agriculture, rainwater harvesting, and sustainable agriculture intensification. Others are more market oriented, aiming at improving market and micro-credit access. Due to the large variability of agro-ecological zones throughout the NENA Region, these measures need to be adequately designed and applied according to specific local contexts and socio-economic realities. This paper will present some of the major results of FAO in strengthening resilience of dryland systems to climate change and related shocks in the NENA Region.

**Keywords:** Adaptation, Climate change, Resilience of agro-ecosystems, Conservation agriculture

### **3. Innovating sustainable land management for dryland development toward the Post 2015 World**

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At the United Nations Sustainable Development Summit on 25 September 2015, more than 150 world leaders adopted the new 2030 Agenda for Sustainable Development, including the Sustainable Development Goals (SDGs). With respect to dryland development, the SDG target # 15.3 states: “By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world”. Sustainable Land Management (SLM) plays an essential role in achieving a land degradation-neutral world. SLM is defined as a knowledge-based combination of technologies, policies and practices that integrate land, water, biodiversity, and environmental concerns to meet rising food and fiber demands while sustaining ecosystem services and livelihoods. By exploring traditional knowledge and reevaluating indigenous technologies, which have been refined over many generations in the region, or developing new appropriate technologies, a variety of SLM technologies are now available. However, we have noticed that there are still challenges in the current SLM to be solved. First, to prevent land degradation and restore degraded land, the soil and water conservation measures should be improved further. Second, effective and efficient SLM approaches, which are defined as the ways and means used to promote and implement SLM technologies and to support them in achieving widespread SLM, should be established. Third, SLM projects should be linked with socio-economic empowerment of local people, to improve their livelihood and assist the socially vulnerable. By innovating SLM through development of eco-friendly and profitable technologies, we must achieve a land degradation-neutral world.

**Keywords:** Sustainable Development Goals, Combating land degradation, Sustainable land management, Traditional knowledge

### **4. Oasis and oasisification in China**

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Oasis is a kind of geographic landscape suitable for plant growth and sustaining human life, supported by stable water resources in desert regions; and it is obviously different from desert landscape. Oasisification is the process of desert transforming toward oasis (usually named artificial oasis), including expansion of oasis size and optimization process of oasis ecosystem structure and function, due to the interventions of human

beings and the natural factors. According to monitoring and evaluation data, the total area of oases in the arid region of northwest China in 2010 was about 210,000 km<sup>2</sup>. Among this, the area of oasisified lands (or artificial oases) expanded to 110,000 km<sup>2</sup> from 25,000 km<sup>2</sup> of the late 1950s. Although oases and oasisified lands, with their scattered distribution, only accounts for about 7% of the total area of the arid region, these are the core areas in the arid areas of China where 27 million people live and engage in production activities, and are also considered as the foundation of the development in the northwest region. Oasisification is a process of natural ecosystem promoted to artificial ecosystem through human activities, but low-level and disorderly exploitation also can decline oasis stability and make oasis degradation. With the reduction or loss of the oasis productivity, unreasonable exploitation of oasis also brings about a series of ecological environment problems, such as rivers cutoff, lakes shrinking, vegetation degradation, soil erosion, etc. Therefore, it is necessary to fully understand the hydrological, soil, air and plant processes of oases and oasisification and their interaction in the context of human activities and climate change, to reveal the oasisification characteristics and their spatial-temporal pattern evolution, process and driving mechanism, in order to provide the scientific basis for establishing the regulation and management modes of oasisification. Through systematic research, we reconstructed landscape pattern change of land use/cover in past 50 years in the arid areas of China, and developed the spatial-temporal evolution rules of oasisification in the study area and its variation characteristics associated with key impact factors. We studied water, energy transfer and transformation, and their interaction mechanism in the process of radiation-water-soil-vegetation interaction about oasisification, and established the feedback and response models among water, soil, air and plants. Especially in the middle and lower reaches of Heihe River Basin, hydrological process of oasisification was studied, the interaction mechanism of water and vegetation in desert ecosystem, and the relationships between hydrological and ecological process at different scales were identified. The distributed watershed hydrological models suitable for arid regions of China were established, and the watershed hydrological variable threshold was determined aiming at oasisification. The distinguishing methods of human activities and climate fluctuation affecting oasisification were put forward and the quantitative analysis model was established. It was found out that the influence of human activities in the oasisification process accounted for over 85%. The research framework and analysis methods of oasisification trend were put forward and the prediction model was built, and the change trend of oasisification in the next 20 to 30 years was analyzed. The decision support system to regulate the relationship between human and earth was established, and the ways of investment to regulate the human-earth system was recommended. The regional target balance method among ecology, economy and environment was established, and the optimization goal of the coordinated development between ecological environment and social economy, and evaluation indicators of objective compatibility degree and balance method was put forward. The final oasis stabilization and oasisification regulation regionalization map was completed.

**Keywords:** Oasis stability, Feedback model, Hydrological processes, Ecological processes, Decision support system, Human-Earth relationship

## **Plenary Session 2**

### **1. The contribution of innovative agricultural research to the sustainable development goals (SDGs) in dry areas**

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In contributing to the Sustainable Development Goals (SDGs) in dry areas, ICARDA over the last 39 years has taken an integrated pragmatic approach in providing solutions to the challenges facing sustainable agricultural development in production systems - rainfed and irrigated agriculture as well as the agro-pastoral systems. This has been through technological improvements to enhance in the way natural resources are managed within the context of agri-food production systems; the conservation and utilization of genetic resources of key staple commodities and the introduction of desirable traits that improve the quantity, quality and efficiency of food production systems. This has contributed to the development sustainable livelihood systems for rural communities. Through its collaborative research and technology transfer with national partners, examples on the ground are presented in the paper to demonstrate how to contribute to the eight SDGs below. Different strategies are used to achieve these goals in different agro-ecologies. These include sustainable intensification in high potential areas and to achieve resilient production systems in marginal lands of the non-tropical dry areas. ICARDA's collaborative research with national partners contributes mainly to the following SDGs: SDG 1, No Poverty: End poverty in all its forms everywhere; SDG 2, Zero Hunger: End hunger, achieve food security and improved nutrition and promote sustainable agriculture; SDG 4, Quality Education: Ensure inclusive and quality education and promote lifelong learning; SDG 5, Gender Equality: Achieve gender equality and empower all women and girls; SDG 8 Decent Work and Economic Growth: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; SDG 13, Climate Action: Take urgent action to combat climate change and its impacts; SDG 15, Use on land: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss; SDG 17, Partnerships for the Goals: Revitalize the global partnership for sustainable development.

**Keywords:** Collaborative research, ICARDA, Sustainable intensification of agriculture, SDGs

### **2. Sustaining water for desert agriculture**

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Although about 1/3 of the world's land surface is covered by deserts and about 40% of the land surface is classified as arid or semi-arid, many of these arid lands can be

among the most productive crop producing areas on earth. With abundant sunshine and generally long growing seasons, the primary limiting factor to crop production is water and, in order to have productive cropping systems in desert climates some type of irrigation is required. In fact, 40% of the world's agricultural crops are produced on just the 17% of cropland that is irrigated. However, as population in the arid regions increases and urbanizes, the competition between agriculture and non-agricultural water uses has resulted in significant pressure on desert agriculture to reduce its water "footprint". There are several ways that this is being achieved. First is the significant improvement in irrigation efficiencies that can be achieved by drip irrigation technology and, in particular, subsurface drip irrigation. Second is development and refinement of appropriate technologies for treating waste water and grey water for irrigation. Third is the improved understanding of how wastewater, both tertiary treated and only primary treated, can be safely used for crop production. Finally, continued improvement of water harvesting techniques and enhanced awareness of the role that water harvesting can play has led to a greater role for water harvesting in both agricultural and urban landscapes. This presentation will investigate each of these technologies and discuss how each or a combination of all can contribute to sustainable crop production in desert agriculture.

**Keywords:** Water harvesting, subsurface drip irrigation, wastewater irrigation

### **3. Towards second green revolution by making grey areas green**

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India has recently celebrated golden jubilee of Green Revolution, which enabled food self-sufficiency. Despite fourfold increase in population, the production of food grains rose by fivefold. In the process, two lessons were learnt. First, the second generation problems of Green Revolution such as: factor productivity decline, poor soil health, water table decline, higher incidence of pests and diseases, increased cost of inputs, decline in farm profits etc. emerged prominently besides adverse impact of climate change. Second, around 50 per cent rainfed area is still deprived of Green Revolution. Thus, the current challenge is to make these grey areas green, requiring a paradigm shift from uni pillar to twin pillar strategy i.e. adoption of both varietal improvement and good agronomic practices (GAP). Hence, the existing divide between irrigated and rainfed regions need to be bridged by insulating farmers against risk by scaling out innovations around pre- and post-production practices for improved livelihood of smallholder farmers. Fortunately, the drylands in India are different in many ways. It's flora and fauna represent unique agrobiodiversity, and considered to be an asset

to cope with emerging abiotic and biotic stresses, besides adaptation and mitigation to climate change. Existing agrobiodiversity for crops, including horticultural crops, grasses, shrubs, trees, animals, so typical of Indian Thar desert, offer ample opportunities for attaining second Green Revolution. Both research and development efforts relating to conservation of biodiversity through use, diversification in farming systems, secondary and specialized agriculture, natural resource management, post-harvest processing and value addition and inclusive market oriented development (IMOD) offer ample opportunity. In this context, exciting developments to scale out innovations around hybrid technology, GM crops, conservation agriculture (CA), watershed management, micro-irrigation, protected cultivation, arid-horticulture, agroforestry, integrated pest management (IPM), precision nutrient management (PNM) etc. are taking place. The presentation would centre around the existing constraints, possible options for scaling new innovations, and required policy interventions for sustainably managing the drylands through second Green Revolution in India.

**Keywords:** Green Revolution, Rainfed agriculture, Conservation agriculture, GM crops

#### **4. Development of salinity and drought tolerant plants through biotechnology**

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The distribution of saline soils on more than half a billion hectare worldwide warrants efficient, economical and environmentally acceptable management practices. In addition, scarcity of water compounded by climate change resulting in long drought spells has warranted development of crops with tolerance to both salinity and aridity. In this context several efforts are being made to understand osmoregulation in living systems.

Studies on halophytic plants and halophilic bacteria can provide useful information in this regard. More recently it has been shown that plant bodies harbor a large number of microbes, more than the number of plant cells. Similar findings have been made for human body. Plant microbiome has been reported to contribute significantly to plant performance and can provide information regarding complex ecological processes involved in osmoregulation of halophytes. Metagenomic based molecular retrieval of 16S rRNA gene (rDNA) sequences have become the most important tools for exploration of microbial diversity. The basic aim of this study is to investigate the microbiomes associated with aboveground (phyllosphere), below-ground (rhizosphere) and internal (endosphere) tissues of halophytes. Culturable bacteria were characterized morphologically, physiologically, biochemically and identified by PCR amplification of

specific 16S rRNA gene sequences. Sixty-two strains were selected after screening for salt tolerance. It has been earlier reported that some of the osmoregulatory genes are present on the plasmid. In order to demonstrate it, plasmid curing of isolates was done by heat shock method, using SDS (3%) and sodium benzoate (130g<sup>l</sup>-1) to study the effect of plasmid conferring salt tolerance. These plasmids were isolated and transformed into *E. coli* and growth response of original strains and transformed *E. coli* was found to develop high salt tolerance at 2-4M NaCl concentration, and thus indicating some of the osmoregulatory genes to be located on the plasmid. The sequencing of the plasmid is underway which will reveal the array of genes responsible. These genes can then be used with appropriate promoters to transform some of the economic crops.

Similarly, exploration of salt and drought tolerance mechanisms in plants has been the focal area of research in many advanced laboratories of the developed world. A series of stress tolerance mechanisms including, osmoregulation, detoxification of reactive oxygen species, late embryogenesis abundant proteins, and regulation of water and ion homeostasis have been reported. The key genes in the abiotic stress tolerance have been identified and studied for multiple kinds of stresses selecting tandem genes for various mechanisms. In addition, the regulatory genes, hormone homeostasis and epigenetic controls have been identified to play very important roles in abiotic stress tolerance in plants. Some of the work carried out will be reviewed.

**Keywords:** Salinity and drought tolerance, Microbiomes, Osmoregulation, Halophytes

## **Plenary Session 3**

### **1. Building a sustainable community in the Egyptian dessert**

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Food security is a major problem in Egypt. Having a population of over 90 million vs. less than 6% of arable land has led to tremendous food imports. On the other hand, healthy wellbeing, quality education, clean water and sanitation, affordable clean energy, decent work, industry innovation, climate change, life on land, peace and justice - nearly all sustainable development goals must be tackled by the Egyptian government, civil society and the private sector together. One of the key solutions is that we have experienced is to build living communities in the dessert. In 1977, the Sekem initiative for sustainable development started reclaiming the dessert land using biodynamic agriculture, through the economic pillar of the Sekem Model, families were hosted, schools, theaters, medical centers and research facilities were established.

To address the environmental challenges, sustainable agriculture methods are exceptionally efficient in carbon sequestration by absorbing greenhouse gas emissions in the soil and trees, which in turn contributes to the raising challenges of global climate change. Moreover, compost production vitalizes the soil, due to being produced from animal manure through modern technology. The harvested organic produce is further processed to high quality phyto-pharmaceutical products, organic food and textile garments. The factories were built up on the same land, providing a job opportunity in the community. The aim of the Sekem initiative is to demonstrate that a holistic approach to sustainable development is possible.

**Keywords:** Food security, Egyptian desert, SDGs, Sustainable agriculture, SEKEM model

### **2. Inquiry Based Science Education (IBSE) for sustainable dryland development**

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Economic development has been and remains the target and priority of each entity, community and country around the globe. However, the global climate and natural disasters pose great challenges especially to the dryland areas. Accordingly, the way of thinking and strategies to tackle the challenges have to be changed. Strategies and solutions developed for irrigated lands cannot be applied as such for the development of

drylands. In addition, the socio-economic and cultural aspects of the communities at large have greater influence on implementation of any development strategy and programme. Therefore, to face the known and emerging challenges to the drylands and to ensure sustainable dryland development, critical and innovative thinking across the board, specially among children, the future of nations, is of utmost importance. And to nurture critical and innovative thinking in the society, especially young children, the methodology of teaching and learning at school level becomes crucial. In this respect, the inquiry based science education (IBSE) approach, especially for the subjects of science, technology, engineering and mathematics (STEM) or STEAM ("A" stands for Arts) at schools, has been recognized globally, as the best methodology for learning of the scientific and technological processes and natural phenomena taking place in the environment and around us. IBSE (inquiry based science education) is the way of teaching and learning, which instills the willingness of learner to explore new ideas and reliance on evidence and logic. IBSE develops understanding of different science concepts through children's own physical and mental activity. In IBSE, different facts, questions, problems and scenarios are presented to the pupils for investigation by using their own skills of observation, raising investigative questions, planning and conducting investigations/experiments, reviewing evidence in the light of what is already known, drawing conclusions and communicating and discussing results. Therefore, IBSE is a step forward to nurture inquisitiveness and to ensure sustainable supply of young talent for linking advance research with sustainable economic development as a whole. The practical IBSE modules developed by dryland experts and pedagogy specialists, can be incorporated in the syllabi of school children, particularly in the dryland areas of the globe; which in-turn can assure the sustainable development of the dryland areas. One such successful model is that of the *Farmer Field Schools (FFS)* originally developed by FAO in the 1980s and has since spread around with certain modifications and has also been practiced by ICARDA projects, at least in Pakistan. The IBSE and FFS, both emphasize on "*inquiry based learning*" or the "*learning by doing*" and "*evidence based decision making*".

**Keywords:** Inquiry based education, STEAM, Dryland agriculture, Farmers field school

### **3. Rainwater harvesting in drier environments: Role in ecosystems restoration and resilience to climate variability and change**

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Rainwater harvesting is an ancient practice that people in dry environments have depended on for survival. It has been used also for agriculture and other purposes. The

practice has lost importance in recent decades due mainly to developing practical and more feasible modern water resources technologies and practices. However, rapid development and increased water scarcity has led to reemphasizing water harvesting as a more sustainable practice especially under changing climate. Although its importance is decreasing for human water supply, its role in combating land degradation and improving rangelands for feed supply and ecosystems services is rather increasing.

This paper addresses the potential role of rainwater harvesting in the restoration and/or the rehabilitation of degraded dry ecosystems. As the vast majority of rangelands dry ecosystems in many parts of the world are severely degraded, it is questionable whether they can be brought back to their original state. The other option is to rehabilitate to bring it up to new system equilibrium. Rainwater harvesting in both cases is essential to overcome the consequences of the degradation of the system by enhancing soil water and halting erosion so vegetation can grow again. Reasons why most of the past attempts to integrated water harvesting in the system restoration had failed and conditions for success are highlighted in this paper. Failure to plan, design and implement suitable water harvesting practices together with lack of integration and follow-up grazing management are some of the important technical shortfalls. However, of most important is the lack of attention and investment given to the restoration of degraded ecosystems. National policies need to be developed to create enabling environments for meaningful investment in both human resources and development projects for dealing with degraded lands in dry areas.

**Keywords:** Rainwater harvesting, Climate change, Rangeland degradation, Policies for restoration

#### **4. Drought proofing through implementation of District Agriculture Contingency Plans in India**

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Deficiency in rainfall during crop growing season results into meteorological drought and agricultural drought leading to substantial reduction in crop yields. The impact of drought on rainfed crops is much higher compared to crops in irrigated regions. The district contingency plans, containing technological interventions, seed, agronomic and water management etc., are prepared for 600 districts and are made available through Ministry of Agriculture & Farmers Welfare (MoA & FW) / Indian Council of Agriculture Research (ICAR)-Central Research Institute for Dryland Agriculture (CRIDA) websites. Drought mitigation measures for delay in onset of monsoon, break in monsoon, mid-

season & terminal drought for all field crops and horticultural crops are covered in these documents. During the years of 2014-15 and 2015-16, CRIDA made substantial efforts in sensitising the line departments, particularly agriculture departments of the states, through national and state level interface meetings to address the deficient monsoon scenarios. Due to continuous efforts, alternate contingent crop seeds were made available to farmers for sowing in delayed monsoon areas thus bringing the agricultural lands into cultivation which otherwise would have become fallow lands leading to distress in agriculture. Collaborative mechanisms were developed between research institutes/ agricultural universities and line departments for monitoring weather information in real time at sub district level. At farmer level, efforts are made to showcase the agricultural contingency measures such as foliar sprays, contingent crops and cultivars, critical irrigation etc. through demonstrations in farmer fields under National Innovations in Climate Resilient Agriculture (NICRA) - Technology Demonstration Component (TDC) and All India Co-ordinated Research Project on Dryland Agriculture (AICRPDA) - NICRA programs. It is possible to make crops withstand long dryspells with series of good agricultural practices and resource conservation technologies. It is necessary to develop seed bank systems for contingent crops, tying up with available minor surface and ground water systems to meet critical irrigation requirements at village/ *taluq* level to ensure the drought proofing of agriculture production systems. Overall objective of district agriculture contingency plan preparation is to ensure food security of the country during weather aberrations and extreme climatic events

**Keywords:** Drought, NICRA, Contingency planning, Demonstrations

## **Plenary Session 4**

### **1. Crop diversity - a prerequisite for food security**

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A growing world population and a constantly changing climate is challenging the global community's ability to feed the world. The clear message from the International Panel on Climate Change is that business as usual is not an option. The world requires more and more nutritious food while a business as usual scenario would reduce food production over the next years. Agriculture is probably facing its biggest challenge ever. We need game changers in the way we do agriculture. The diversity contained within plant genetic resources provides a universe of untapped possibilities. It holds the variability needed for adaptation, and has the potential to serve as a key element in maintaining food production under novel temperature, precipitation, pest and disease conditions. This diversity is increasingly threatened, and there is an urgent need to collect and secure plant genetic resources for the global community.

**Keywords:** Plant genetic resources, Genetic diversity, Climate change, Food security

### **2. Exploitation of useful genes in wheat-wild species for sustainable agriculture in dry areas to achieve SDGs**

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From 1960's wheat has been improved and designed to be highly responsive to the high inputs of water and fertilizers to produce a high yield (Green revolution). As a result, the production increased three times over the last five decades. Reduced height or semidwarf genes (*Rht1*, *Rht2*, and *Rht8*) were the key genes in this breeding process. These derived from Japanese wheat cultivars 'Norin 10' and 'Akakomugi'. The far origin of the green revolution genes from the wheat birthplace clearly shows the importance of novel genes exploration. To secure enough food for the increasing population, we have to breed more productive wheat varieties. Currently, the annual yield increase is rather slowed down because of dissemination of the improved varieties with semi-dwarf genes all over the world and the lack of new genetic variation in the wheat gene pool. Thus, it is an important issue to exploit novel germplasm for the breeding of the future varieties. However, in this breeding, we will have to consider the unsustainability of the high input agriculture (green revolution) under the situation of scarce water and fertilizers. In this presentation, I will show our research efforts to find desirable genes from wheat-related wild species. We produced many wheat lines with wild genes by the means of wide

hybridization. These lines have been evaluated for several traits including abiotic stress tolerance. Several lines possess heat or salinity tolerance, increased mineral contents, and high bread-making quality. Now we are seeking other useful genes in diverse populations termed multiple synthetic derivative (MSD) harboring genes from wild species.

**Keywords:** Wheat improvement, Novel wheat-related germplasm, Wide hybridization, Abiotic stress tolerance, Bread making quality

### **3. Paddy cultivation in dry regions - Implication and future directions**

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Paddy cultivation plays significant and vital role in rice production. Most of the global population depends on the 480 million tons of rice produced each year as the basis for their lives. While about 90% of the world's 160 million hectares of paddy fields are in Asian countries, mainly in monsoon regions, paddies are also seen in North America and Africa, even in dry regions where irrigation has reclaimed dry land for paddy fields. Most of paddy fields are inundated naturally or artificially during rice production period. In the case that paddy fields are kept submerged artificially, some infrastructures like water intake, diversion and canals are required. Paddy fields with irrigation system produce traditionally much rice, taking benefits of stable water supply and continuous ponding. Paddy fields are simultaneously performing other functions for local environment, including climate mitigation, flood control, groundwater recharge, bio-diversity and ecosystem development, and so on. Recently, these are recognized as the multi-functions of paddy fields. The sustainable water delivery and ponding has established local water management society, which is mainly represented by organization of water users, usually farmers. This society or organization could work not only for paddy cultivation but also for total rural life of the region. On the other hand, since paddy fields require much water and modify the original and natural hydrological regime, they might cause adverse effect on local environment. Irrigation sometimes needs drainage system, which also might alter local water balance. Especially paddy fields in dry land, and even in dry condition in humid region, might modify hydrological regime to much extent inducing problems with too less water in some areas and too much water in others. In this paper, paddy cultivation in dry region is reviewed comprehensively with various aspects, for establishing much sustainable system.

**Keywords:** Paddy rice, Submerged paddy cultivation, Upland rice, Irrigation

#### **4. Can selection in pasture grazing systems reduce methane production from ruminants?**

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Greenhouse gas (GHG) emissions are of major concern globally. Methane is one of the most potent heat-trapping gases with half of CH<sub>4</sub> emissions from the agricultural sector coming from ruminal enteric fermentation. Pasture species differ widely in fermentative traits, including methane production, indicating that the choice of fodder species may offer a way to reduce the environmental impact of enteric fermentation in drylands. A stand-out in this regard in Australia is biserrula (*Biserrula pelecinus* L.) with its particularly low levels of methane output when fermented by rumen microbes. The Mediterranean species biserrula is an important annual pasture legume for the wheatbelt of southern Australia. The anti-methanogenic activity of biserrula can be linked to compounds contained in selected bioactive fractions, with specific fractions found to strongly affect key rumen methanogenic archaea (methanogens). In addition to differences in methanogenic potential between species, there are also heritable differences in methanogenic potential within species such as biserrula and subterranean clover (*Trifolium subterraneum* L.) - the dominant pasture legume in southern Australia. In the light of this information on feed, the paper discusses novel strategies to control methanogen populations and activity in the rumen, and consequently contribute to a reduction in greenhouse gas emissions from ruminants while maintaining system productivity.

**Keywords:** Green House Gases, Enteric production of methane, Bierrula pelecinus, Anti methanogenic activity

## **Plenary Session 5**

### **1. Greater Central Asia as the new frontier in the Twenty-first century**

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This paper is an analysis of developments in the relationship between China and the neighboring countries with special reference to likely impact of Chinese initiatives to bring about closer integration. The countries of Greater Central Asia (GCA) have always acted as a land bridge along the major commercial routes between Europe and Asia. Central Asia (*sens lat*) was once the hub of the Silk Road and if a Silk Road Economic Belt is realized, it would be so again. The development of this economic area hinges on the full development of Central Asia. Although the Central Asian area is rich in mineral resources, it remains an underdeveloped area. And the total population of the Central Asia is only 60 million, almost equivalent to a middle-sized province of China. So, in China's push for westward opening-up, it is incumbent for it, on the basis of a good Central Asia development strategy, to foster a broader cooperation of 3 billion population involving the Central Asia, West Asia, South Asia, even dozens of European countries. The significance of the concept lies in the creation of a Silk Road Economic Belt that links China's most vigorous Yangtze River Delta, Pearl River Delta and Bohai Sea economic zones to the European economy. The special role of the proposed New Silk Road Belt being promoted by China is examined against the historical past (distant past and since the independence of the post-Soviet republics in 1991). The implications of the newly developed and planned transport networks (road and rail-road shipping and air routes) for trade in goods and services and the potential for one or more of the 5 '*stans*' to be a hub is considered. There are barriers to be overcome if the dream of an integrated and cooperative GCA is to be realized. I believe that China does not seek to create a sphere of influence, and instead strives to construct with the Central Asian countries a community of shared destiny and a community of shared interests. Only by jointly building a Silk Road Economic Belt can Central Asian countries create a new geopolitical situation and promote GCA to its place as a hub between Asia and Europe. By 2030 (under this scenario) the entire territory of GCA will be covered with a great infrastructure of highways, railways, airports, and logistics centers that will handle goods and passengers moving between Europe and Asia

**Keywords:** Silk Road Economic Belt, Integration with European economy, China, Greater Central Asia

## **2. Breeding wheat and barley for the drought-prone conditions in the Kyrgyz Republic**

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Wheat and barley are the major crops of the country. They occupy almost half of the total crop area and ensure food security. Breeding work was conducted by the Kyrgyz Research Institute of Agriculture in the arid zones of the country to develop improved varieties. New varieties of winter wheat ‘Erythrospermum 760’, ‘Adir’, ‘Kairak Ehol’ have the potential yield on unirrigated land up to 5 tons per hectare, with a protein content of 14.5 percent, and gluten content of 29 percent. Spring barley area is located mainly on non-irrigated lands. Early ripening varieties such as ‘Naryn 27’, ‘Nutans 970’, ‘Taalai’, ‘Best’, ‘Vladlen’ are characterized by accelerated growth of plants to heading, enabling them to head before the hot and dry weather (temperatures of 30° C). Grain yield of spring barley varieties on unirrigated lands is 2.2 tons per hectare, with a protein content of 16 percent. The institute produced 3 more varieties of winter barley from the germplasm obtained from ICARDA. They are ‘Adel’, ‘Zhenish’ and ‘Belek’, which are drought-resistant and early maturing. Under unirrigated conditions they have a potential yield of 5.7 tons per hectare with 14 percent protein. All of the above mentioned varieties of spring barley and winter wheat are being successfully grown in the dry areas of Kyrgyz Republic by our farmers and cooperative farms.

**Keywords:** Winter wheat, Spring barley, Crop improvement, Dry areas of Kyrgyz Republic

## **3. The role of Sinai University in achieving sustainable development in dry land ecosystem of in Sinai**

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The liberation of the holy land of Sinai inspired me to focus all my investments intensively to contribute in rebuilding the economy of the peninsula through projects in the industrial and tourism sectors. During the course of our investments, I decided to establish a university at Al-Arish /North Sinai to despite being challenged by many of my colleagues, business partners, experts and even within my family expressing their doubt on the financial feasibility of having a private university in dry land area with limited human and natural resources. My project was seen before its birth as risky and infeasible from the economic standpoint.

Contrary to common wisdom, my perspective was that education in marginal areas as Sinai would enable development and accordingly optimizes the economic opportunities for investment. Therefore, my insistence to establish Sinai University was based on sincere belief and full understanding that education has the power to reverse all negative impacts of insecurity on societies and economies in Sinai, which have been always exacerbated by political marginalization of the local communities in Sinai and slow growth of health and education infrastructure. Given the fact that Sinai University is surrounded by poor communities, high consideration has been given, since its inception in 2006, to the social dimension which has annually amounted to 10 % of the total budget in the form of full scholarships, tuition fees discount, and small projects to serve the local communities and create jobs. After ten years of witnessing the socio-economic impacts of Sinai University, I feel proud and satisfied irrespective of all challenges and constraints. The main factor of success was our intention from the beginning to design our own educational curricula that specifically meet the social and environmental challenges of Sinai and connecting scientific research with community needs. However, the success of Sinai University in Al-Arish has encouraged the Board of Trustees to establish another campus in EL-Qantra city, which is located in Suez Canal area /Ismailia governorate. The new campus is equipped by all means and tools representing the state of the art technologies. It is worth to note that Sinai University is very keen to conduct extensive research directly addressing the dry land ecosystem challenges of Sinai as desertification control, rehabilitation of degraded land, ground water management, sand dune encroachment and plant genetic resources conservation and utilization. Moreover, the dry land ecosystem challenges are included as cross-cutting issues in the educational curricula in order to make graduate generations capable of achieving real sustainable development.

**Keywords:** Economic opportunities for investment, Education, Scientific research, Community needs, Dryland ecosystem challenges, Desertification control

#### **4. The nanotechnological approaches for 2030 Sustainable Agriculture Development Strategy**

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The Egyptian Sustainable Agriculture Development Strategy 2030 (ESADS 2030) is established on knowledge-based economy approaches, using the most modern technologies and rapid technology transfer. Nanotechnology is one of the important components of ESADS 2030, especially for the reclamation of new lands. Implementation of a suite of nanotechnology applications is being attempted in most

sectors of agriculture such as water treatment, nano-fertilization, nano-pesticides, nano-biosensors, treatment of plant and animal diseases and nano-foods, taking into considerations the safety requirements. The present paper will emphasize the role of green nanotechnology in the Egyptian Sustainable Agriculture Development Strategy 2030, with the aim of building up the Egyptian society on the bases of good knowledge and strong economy.

**Keywords:** Nanotechnology, Agricultural applications, Egypt, Sustainable development

## **5. The role of the Sustainable Development Center for Matrouh Resources in the Development of Drylands at Matrouh Governorate**

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The North Western Mediterranean Coastal Belt, which extends from Alexandria westward to El Sallum, is considered the richest part of Egypt in flowering plants, owing to its relatively high rainfall. In addition, the area has several *Wadis* running from south to north and represent suitable environment for cultivating fruit, vegetables, barley, and growing native plants. The North West Coast (NWC) and its inland desert suffer from a fragile socio-economic structure, with a modest contribution to the country's GDP not exceeding 0.7%, although covering over 16% of Egypt's geographic area. The major constraints include: limited water resources (low rainfall, low WUE, shortage of water harvesting technology); degraded plant resources (deterioration of plant cover, over grazing, fire wooding, poor rangeland management), and degraded soils (low soil fertility, salinity and erosion). In 1994 the Egyptian Government, with a World Bank (IDA) credit and contributions from its beneficiaries, established the Matrouh Resource Management Project with a total budget of 29.4 million USD. The objectives were to conserve the natural resource base (water, land and vegetation), implement programmes for sustainable natural resource management and alleviate poverty and improve the livelihood of the local Bedouin population, and provide support to improve resource management practices, agricultural production improvement and socio-economic development. With a strong adaptive research and technology base, the Project served an area that stretched 320 km along the NWC, from Ras El-Hekma in the East to El-Salloum on the Libyan border in the West, and about 60 km inland. At the end of the World Bank funding in 2002, funding started from the national budget as the project was very successful in improving Bedouin livelihoods. Later, it was named as 'Sustainable Development Center for Matrouh Resources' (SDCMR) and affiliated to the Desert Research Center, with a special budget allocation from the Ministry of Finance. The budget was lately reduced to about 1 million EGP, necessitating a curtailment of activities. The SDCMR follows a participatory approach in the development of the area

giving the local community greater responsibility in managing, implementing and evaluating their activities (construction of cisterns for the rain water harvesting, construction of the dykes, rangeland management, participatory plant breeding for selecting the superior barley genotypes, etc.). It is currently the primary stakeholder in research and development of drylands of Matrouh Governorate, cooperating with several international partners in conservation and development of Matrouh ecosystems. As a part of the Mediterranean region, NWC is a hot spot for climatic changes, affecting agriculture, rangeland livestock production, and ecosystems services. Although the average annual precipitation is 1 billion m<sup>3</sup>, less than 30% is harvested. SDCMR has constructed 9413 cisterns with a total capacity of 1.4 million m<sup>3</sup>, 530 reservoirs with a total capacity of 70,000 m<sup>3</sup> and rehabilitated 245 Roman cisterns with a total capacity of 100,000 m<sup>3</sup>. The area has 258 *Wadis*, but only 70 are developed (59 by the SDCMR). Thus, there is an urgent need for more rainwater harvesting structures. More international and national cooperation is being sought to strengthen project activities to alleviate poverty and satisfy the rural development needs of Bedouins in NWC region.

**Keywords:** Northwest Mediterranean Coast, Water harvesting structures, Wadis, Rangeland management, Participatory plant breeding

## **Plenary Session 6**

### **1. Vegetative landscaping of desert**

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Desert native plants play an important role under arid and semi-arid conditions. These plants provide the main source of food for most organism living under desert conditions (i-e. animals, insects and microorganism). The vegetative cover of desert plants depend on rain density and distribution. These plants are adapted to all hard desert conditions and can grow and propagate well under arid and semi-arid conditions. There is a wide range of plants that can be used in desert landscape, having low water requirement, salt and heat tolerance, low maintenance requirements, sand storms tolerance, ability to grow under low fertility soils and easy to propagate. Native plants nurseries play an important role nationally and internationally for desert landscaping, desert reclamation for increased food production and production of high cash exportable crops (peanuts, fodder crops, fruit trees, vegetables, medicinal and aromatic plants, native ornamental plants and ornamental plants and cut flowers). National and global attention is needed to protect desert native plants by governments, civil societies and political parties by formulating appropriate regulations and policies.

**Keywords:** Native plants, Vegetative cover, Desert landscape, Medicinal and aromatic plants

### **2. Potential of agroforestry in drylands**

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Unsustainable land and water use is enhancing the impacts of climate change and further hastening the degradation of drylands. The most serious challenge faced by drylands of the world is how to maintain and/ or improve food and nutritional security of the communities living in dry areas? Growing food and nutritional insecurity in the drylands calls for concerted and consorted actions at local and global levels. Trees and dryland forests do not receive much attention because these are not as attractive as the tropical trees and forests. Though, such plantations occupy about 11 percent of the global forest area, and up to two billion people depend on these forests and pastures for their food and livelihoods. Fuel obtained from these ecosystems accounts for between 50 and 90 percent of energy used in Africa. But unrestricted forest clearance for agriculture and

fuel wood has far exceeded the ecosystem's capacity to regenerate naturally. To better quantify and manage these plantations and forests in drylands, a better system of mapping and monitoring is needed. Landsat images have serious spatial resolution problems in the drylands, because individual trees cannot be resolved. New resources, such as Google Earth, actually show the individual trees. FAO has developed the 'Collect Earth' system, which is a Google Earth plugin for forest sampling analysis that even untrained people can use to conduct a field survey actually on screen. The Rapid Land Cover Mapper, developed by the United States Geological Service, maps land use and land cover over large areas and through time, and again can be downloaded for free, and used by non-experts. ICRAF has developed various kinds of geospatial tools to help map and monitor agroforestry. It is increasingly evident that agroforestry is one way to solve the problems faced by people living in the drylands who depend on trees for their livelihoods. Agroforestry systems are known for promoting the best land use practices in drylands. These systems provide farmers with a portfolio of diverse products, both to sell and consumes and ensure higher productivity/ unit of land. They produce more nutritive food, fodder, fuel, timber, non-timber products like, gum and resin etc.; and extend extremely important environmental services both below and above the surface. Besides, they help communities to be more resilient to increasing climate change, and provide safety net against crop failures during extreme weather and natural calamities like floods and droughts. The importance of agroforestry is reflected from the fact that India in 2014 became the first country globally to formulate and implement a National Agroforestry Policy where ICRAF was involved as a technical partner. Nepal and Bangladesh are also on the way to develop their own National Policies with support from ICRAF.

**Keywords:** Agroforestry systems, 'Rapid Land Cover Mapper', 'Collect Earth', Drylands, National Agroforestry Policy, Climate change

### **3. Role of farm level water harvesting in drought mitigation in smallholder dryland farms in India**

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Despite extensive development of irrigation over the years, nearly 50 per cent of the net sown area in India is under dryland agriculture. Delay in monsoon arrival and midseason breaks cause considerable yield reduction in cereal grain crops, pulses, oilseeds and cotton. Research across India over several years has revealed that *insitu* and *exsitu* water conservation are key strategies to mitigate the impacts of droughts on agriculture production and farmers' livelihood. Harvesting surplus runoff during heavy rainfall events in dug out ponds and using it for providing supplemental irrigation during dry spells is one of the most important strategies experimented successfully across the

country. The dug out ponds can vary between 500 to 2000 m<sup>3</sup> and require to be lined in case of alfisols. Such ponds have been dug on farms of small holders under the Government of India's employment guarantee scheme, and the cost of lining, lifting water through portable pump sets, yield benefits due to supplemental irrigation have been worked out for a number of crops. The economic performance of 500 such ponds dug in different agro climatic regions of the country was evaluated with crops such as sorghum, cotton, oilseeds, vegetables and tobacco. The designs of ponds for various rainfall zones, soil types and the volume of water that can be harvested annually have been computed. Currently the Government of India has included the farm ponds scheme as a flagship programme in the *Pradhan Mantri Krishi Sinchan Yojana* (Prime Minister's Irrigation Scheme).

**Keywords:** Dryland agriculture, Water harvesting, Farm ponds, Alfisols

#### **4. African holistic worldview paradigm for interdisciplinary climate change science**

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Available data shows oxygen partial pressures in human blood vessels; vein, bone marrow, lung capillary, as well as atmosphere constitute, approximately, a Fibonacci sequence; 5: 8: 13: 21 % (Common ratio  $\approx 1.6\dots$ ; *phi*). Human life is, therefore, integral to a phi-equilibrium oxygenosphere of Earth. Current Earth climate change crises is, significantly, a phenomenon of oxygen and some of its compounds; oxygen (O<sub>2</sub>), ozone (O<sub>3</sub>), carbon dioxide (CO<sub>2</sub>) and water (H<sub>2</sub>O) in dynamic interaction with energy. Climate change crisis is human-made; anthropogenic. Crisis resulted, inadvertently, from the failure of current social system models and their guiding 'Science of Society'. The inability of current paradigm of science to deal with 'holistic complexity', such as biosphere, is suggested to have led to this. Sciencing from African holistic network worldview is argued to be capable of obviating this problem. Some of the critical elements of this world system are naturalism, holism, networkingness, and synergism. This paradigm is employed to re-interpret, for example, some existing socio-economic data (e.g income size distribution and un-employment), revealing underlying natural laws. The single most important solution to climate crises in sight is naturalization of human society. Malarial parasite life-cycle is seen as cruise up-and-down the oxygenosphere gradients, and logical treatment as oxygen/ozone. Attention is drawn to the existential risk, to humans, of perturbing the natural balance of the phi-equilibrium oxygenosphere. Importance of re-greening the Earth through regenerative agriculture, informed by integrated science, is discussed. A focus on oxygen and its relevant compounds, in dynamic interaction with energy, in the restoration of sustainable green biosphere from current risky 'brown humanosphere' is advocated.

**Keywords:** Oxygenosphere, Holistic complexity, Ozone, Malaria, Size distribution, Webocosmos, Synergism, Biosphere, Regenerative agriculture

## **5. New irrigation techniques for optimizing water use in new land development in Egypt (The first priority - 1.5 million Feddans)**

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Egypt has a total land area of approximately 1 million km<sup>2</sup>, most of which is desert and only 5.5 % is inhabited. Settlements are concentrated in and around the Nile Delta and its valley. The total cultivated land area is about 8.6 million Feddans, ie. 3% of the total land area, and consists mostly of the old and newly reclaimed areas. Water resources are the critical factor for all production and service processes and sustainable development in Egypt. The water resources availability for the whole economic and services activities is extremely dependent on the River Nile, its quota of Nile water is still fixed at 55.5 billion m<sup>3</sup>/year, and this quota constitutes 90% of the country's water budget, the remaining 10% being minor quantities of renewable and fossil groundwater plus a few showers of rainfall. Agriculture is the major consumer of water (80-85% of the total net demand) , as Egypt lies in the arid zone where nearly all agriculture depends on irrigation. Under the 1<sup>st</sup> Priority Land Reclamation Projects of the New Land Development in Egypt, it is planned to reclaim 1.5 million Feddans of agricultural land in 17 reclamation areas in the Western Desert. Some 1.328 million Feddans will be irrigated with groundwater, and 172,000 Feddans with surface water. The groundwater is being extracted from the large water bearing formations constituted by the extensive Nubian Sandstone Aquifer (NSA) and the overlying Post Nubian Aquifers Systems. One of the main objective of the Sustainable Agriculture Development Strategy 2030 is to improve irrigation water use efficiency while the main goals are: sustainable utilization of natural agricultural resources, improvement of the agricultural productivity for increasing the value of crop production per unit land and water unit, expanding the use of modern and well developed irrigation techniques, promoting land reclamation, developing farming systems, and sustainable development of rain-fed agriculture. The study will cover the selection of suitable irrigation systems based on proposed crop patterns and soil classification of reclamation areas, which will play an important role in the success of the project for optimal use of available water resources.

**Keywords:** Irrigation systems, Water quantities, Land reclamation, Sustainable agriculture

## Presentations in special sessions

### Special Session 1: Genomics of Stress Tolerance in plants

#### 1. PCD-related genes and transcription factors affect salt tolerance in plant

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This speculation was based on a natural exciting phenomenon suggesting that suppression of genes or transcription factors (TFs) inducing programmed cell death (PCD) might confer tolerance against abiotic stresses in plant. First, PCD-related genes were induced in tobacco leaves via the treatment with oxalic acid (OA, 20 mM) for 24 h. RNAs were extracted from cells 0, 2, 6, 12 and 24 h after treatment for deep sequencing and RNA-Seq analysis was done with a special emphasis on PCD-related genes up-regulated after 2 h of OA exposure. A number of PCD-related genes were knocked down via virus-induced gene silencing (VIGS) and results indicated the influence of some of them on inducing or suppressing PCD. Knockout T-DNA insertion mutants of these genes in *Arabidopsis* were tested under salt stress (0, 100, 150 & 200 mM NaCl) and the results indicated that the mutant of an antiapoptotic gene, namely *Bax Inhibitor 1 (BI-1)*, whose virus-induced gene silencing (VIGS) induced PCD in tobacco, was salt sensitive, while a mutant of an apoptotic gene, namely *mildew resistance locus O (Mlo)*, whose VIGS suppressed PCD, was salt tolerant as compared to the WT (Col) control. These data support our hypothesis that retarding PCD-inducing genes can result in higher levels of salt tolerance, while retarding PCD-suppressing genes can result in lower levels of salt tolerance in plant. Then, genes up-regulated after 2 h of OA treatment with known function in PCD were utilized as landmarks to select transcription factors (TFs) with concordant expression. Knockdown mutants of these TFs were generated in tobacco via VIGS in order to detect their roles in PCD. Knockout T-DNA insertion mutant of *Arabidopsis* as well as over-expression lines of one TF, namely ERF109 were tested under salt stress (0, 100, 150 and 200 mM NaCl) and results indicated the involvement of this TF in retarding PCD in tobacco and conferring salt tolerance in *Arabidopsis*.

**Keywords:** Abiotic stress tolerance, Programmed Cell Death, Arabidopsis

#### 2. Field evaluation of transgenic wheat (*Triticum aestivum* L.) overexpressing barley chitinase gene conferring resistance to wheat rusts and powdery mildew

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The study aimed at improving fungal resistance in bread wheat via genetic transgenesis. Transgenic wheat harboring barley chitinase (*chi26*) gene driven by maize *ubi* promoter was obtained using biolistic bombardment. The herbicide resistance gene, *bar*, driven by the *CaMV 35S* promoter was used as a selectable marker. Molecular analyses proved the integration, copy number and level of expression of *chi26* gene in five independent transgenic lines. Chitinase enzyme activity was detected using standard enzymatic assay. Variation in *chi26* gene expression levels of the different transgenic events as compared to their respective controls was proven using qRT-PCR. The transgene was silenced in some transgenic families across generations. Gene silencing in the present study seemed to be random and irreversible. Homozygous transgenic plants of the T4, T5, T6, T8 and T9 generations were tested in the field for five growing seasons to evaluate their resistance against rusts and powdery mildew. The results indicated higher chitinase activity and transgene expression levels that resulted in higher resistance against wheat rusts and powdery mildew in field conditions. Proximate and chemical analyses indicated that the transgenic and non-transgenic lines are substantially equivalent.

**Keywords:** Bread wheat, Fungal resistance, Transgenic wheat, Chitinase

### **3. Metabolomic response of *Calotropis procera* growing in the desert to changes in water availability**

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Water availability is a major limitation for agricultural productivity. Plants growing in severe arid climates such as deserts provide tools for studying plant growth and performance under extreme drought conditions. The perennial species *Calotropis procera* used in this study is a shrub growing in many arid areas that has an exceptional ability to adapt and be productive in severe arid conditions. We describe the results of studying the metabolomic response of wild *C. procera* plants growing in the desert to a onetime water supply. Leaves of *C. procera* plants were taken at three time points before and 1 hour, 6 hours and 12 hours after watering and subjected to a metabolomics and lipidomics analysis. Analysis of the data reveals that within one hour after watering *C. procera* has already responded on the metabolic level to the sudden water availability as evidenced by major changes such as increased levels of most amino acids, a decrease in sucrose, raffinose and maltitol, a decrease in storage lipids (triacylglycerols) and an increase in membrane lipids including photosynthetic membranes. These changes still prevail at the 6 hour time point after watering however 12 hours after watering the metabolomics data are essentially indistinguishable from the prewatering state thus demonstrating not only a rapid response to water availability but also a rapid response to loss of water. Taken together these data suggest that the ability of *C. procera* to survive under the very harsh drought conditions prevailing in the desert might be associated with its rapid adjustments to water availability and losses.

**Keywords:** Water availability, Metabolomic response, *Calotropis*, Desert environment

#### **4. Development of transgenic wheat (*Triticum aestivum* L.) expressing *AtMDAR1* gene conferring salt tolerance**

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Monodehydroascorbatereductase (MDAR), an important enzyme of the ascorbate–glutathione cycle, is involved in salt tolerance of plants through scavenging of reactive oxygen species (ROS). In this study, a cDNA encoding *AtMDAR1* gene from the *Arabidopsis thaliana* plant was introduced into wheat plants of ‘Bobwhite 56’ cultivar using biolistic. Copy numbers and expression of *MDAR1* gene were tested in five stable transgenic plants (MD1, MD2, MD3, MD4, MD5) by molecular analysis. Accumulation

of ascorbic acid (AsA) in transgenics was greater than the non-transgenic plants. In a greenhouse experiment, transgenic plants showed more vigorous growth than the non-transgenic plants (Bobwhite56) at 200mM NaCl. In a high salt medium, transgenic plants (MD5 and MD6) had higher dry mass, shoot and root length, and higher tolerance index ( $T_i$ ) in comparison to the non-transgenic plants.

**Keywords:** Monodehydroascorbatereductase, Salt tolerance, *Arabidopsis thaliana*

## **5. Optimization of regeneration conditions and transformation of sorghum genotypes for drought stress tolerance**

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Sorghum (*Sorghum bicolor* L.) is an important crop in many tropical regions of the world, yet it has received little attention in applying modern biotechnologies in its improvement due to regeneration and transformation difficulties. Drought stress is among the most important factors limiting the productivity of sorghum. Optimization of tissue culture conditions for *Sorghum bicolor* L. through somatic embryogenesis from immature embryos is important for the genetic manipulation and improvement of this agronomically valuable crop. A group of 10 sorghum genotypes including locally adapted and commercially important elite genotypes were assessed for their regeneration potential on different culture media– containing adequate growth regulators combinations. Results showed that regeneration of sorghum genotypes could be improved through the use of different auxins and cytokinins in callus induction and shoot formation media. The auxin, 2,4-D was critical for the induction of embryogenic calli. However, the addition of the cytokinin (kinetin) adversely affected the formation of embryogenic callus. On the other hand, the shoot induction was more influenced by the addition of indole-3-acetic acid (IAA), 6-benzylaminopurine (BA) and thidiazuron (TDZ). Previous investigations have shown that the Mitogen Activated Protein Kinase (*MAPKKK*) gene confers tolerance to adverse environmental conditions. The present work was conducted to determine the amenability of sorghum genotypes to *Agrobacterium*-mediated transformation with the tobacco *MAPKKK* (*NPKI*) gene and to analyze the role of that gene in *Sorghum bicolor*. The *NPKI* gene along with the *bar* gene were successfully introduced into two sorghum genotypes, ‘Dorado’ and ‘SPGM94021’. The transformation frequencies were 1.49 % and 1.79 % for Dorado and SPGM94021, respectively. Stable integration of the transgenes in  $T_0$  and  $T_1$  plants was confirmed through PCR and Southern blot analyses. The expression of the *NPKI* gene was detected on the molecular level through real-time RT-PCR analyses. Transgenic  $T_1$  plants tested *in vitro* for tolerance to mannitol osmotic stress maintained a higher growth rate and showed increased tolerance to stress

conditions compared to the non-transgenic plants. Subjecting three-week old seedlings to water withholding periods revealed a higher potential of the transgenic plants to recover after irrigation than the control plants. Accordingly, the *NPk1* gene might induce a mechanism that protects sorghum plants against possible water-deficiency stress conditions.

**Keywords:** Transgenic sorghum, *Agrobacterium*-mediated transformation, Water deficiency stress

## **Special Session 2: Paddy Cultivation in the Dry Areas**

### **1. Developments and prospects of paddy fields in California, USA**

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Paddy fields (flooded rice fields) were introduced in California long time ago and the state is noted for having the second largest paddy field area in the USA. With an average annual rainfall of approximately 630mm, the state of California gets less rain than the national average (approximately 1000 mm). Several water resources development projects such as CVP (Central Valley Project) and SWP (State Water Project) were constructed and are in operation in California to meet the water deficit particularly during the irrigation period. However, in recent years, the state is facing difficulties to secure water supply for irrigation because of the continuous drought along with the increase in demand of water for other uses. Therefore, the task of increasing substantially the current level of production or increasing the land area of paddy fields has become more difficult than it was a decade ago. Generally, paddy fields require much water than other agricultural lands. However, they give far more benefits than merely that out of rice cultivation. The roles of paddy fields in biodiversity and ecosystem conservation, similar to those of natural wetlands, are well-recognized. Furthermore, paddy fields *alleviate* a significant *amount* of the effluent loads of nutrients compared to other agricultural lands. This study will focus on the current status and analyze the future prospects of paddy fields in California while looking at the paddy field situation in Japan.

**Keywords:** Paddy fields, Biodiversity, Ecosystem conservation, Natural wetlands

### **2. Impact of climate change towards irrigation operations in Central and Northeast Thailand and its adaptation towards SDG**

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Recently, Thailand had suffered from both floods and drought, which has caused huge damage to the country's socio-economics. Irrigation management in the country has different characteristics by area due to the topographical and meteorological conditions, i.e., wet area in the central plain (with 6 dams and annual rainfall of 1100-1500 mm) and dry area in the north east (with 10 dams and annual rainfall of 800-1200 mm). This makes the operation rules of irrigation dams different. In the future, as the climate change will induce more fluctuations in the hydrological parameters, the impacts of climate change on irrigation operation in the changing meteorology should be explored

comparatively in the wet and dry areas, at both project and farm levels. This study investigated the hydrological change and the impact of climate change on irrigation dam operations (runoff, storage, release) in the central and north east area of the country. The study used the climate data from MRI-GCM (scenario A1B) with the periods of present (1979-2012), near future (2015-2039) and far future (2075-2099). Due to higher temperature and more fluctuating precipitation, the runoff into the dam will change and the irrigation demand will increase, which will cause changes in the water shortage. The field survey with farmers on the adaptation means to such a change was conducted. The study found that in the central plain, runoff into the dam will increase about 1.35-2.28 % while in the northeast runoff will reduce by about 24-25 % due to rainfall decrease; the irrigation demand will increase due to higher temperature which will induce more water shortage in the northeast area than in the central plain. Hence, the rules of water release from dams will need modification. Seasonal forecasting tools are essential to determine appropriate irrigation cultivation area in each year especially in the northeast area to cope with irrigation water shortage in the changing climate environment in the future. On farm level, farmers are prepared for supplementary irrigation water sources in the dry year such as pumping water from drainage canals, farm ponds, tube well and shallow groundwater to get more sustained production.

**Keywords:** Climate change, Irrigation, Operation, Water shortage, Adaptation

### **3. Paddy rice irrigation and water requirements with upland crop rotation system in the lower Ili River Basin, Kazakhstan**

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Large-scale irrigated agriculture had been developed since 1960's in the lower part of the Ili River, where paddy rice and upland crop rotation has been practiced. Continuous irrigation of paddy rice and once or twice irrigation of upland crops have been conducted. Conveyance and distribution efficiency are very low since all irrigation canals are earthen. Seasonal irrigation water requirements (IWR) of paddy rice was about 8,000 mm in 1960s. Later, irrigation requirements were reduced several times and currently set as 2,290 mm/season. there appears no scientific justification for the reduction. We discussed the meaning of paddy rice irrigation in this district and determined the IWR for paddy rice. Seepage from irrigation canals and deep percolation from paddy rice fields raise groundwater table of surrounding upland crop fields. Shallow water table provides upland crop fields with additional water by capillary. This system increases soil salinization. Therefore, after 3 year of upland crops cultivation it is

necessary to convert to paddy rice cultivation in order to leach out the accumulated salts. Dividing the irrigation district into 4 blocks: North, East, Central and West, the estimated IWR of the West block was the largest followed by the East, Central and North respectively. Therefore, the IWR for paddy rice should not be uniform over the district. On the other hand, it was found that the IWR can be set uniformly within each block as difference are small. The current IWR is quite low compared with the estimated one. If the current IWR is decreased in the near future, agricultural infrastructure and staff reform will be required to upgrade the efficiency of water delivery and distribution.

**Keywords:** Upland paddy rice, Irrigation water requirement, Agricultural infrastructure

#### **4. Cross-scale hydro-dynamics and effects of paddy cultivation on water management and productivity**

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In Egypt, decisions on agriculture and irrigation, such as cultivating periods, crop type and rotation, water allocation and distribution, depend on farmers experience and socio-economic options. Therefore, analysis of cross-scale hydro-dynamics and effects are getting more important in water management, especially under rice cultivation areas as well as at the tail end of irrigation system. The Government of Egypt started implementation of Irrigation Improvement Project (IIP) in 1991 to save water and increase land productivity. The Government has tried to limit rice cultivation because of limited water resources. Unfortunately, in spite of that, rice cultivation has continued to expand due to high profits from rice production. The impacts of increasing rice area have, therefore, got to be analyzed from hydro-dynamics point of view. Many changes have also been taking place in the field conditions because of this increase in rice production, such as water insufficiency, rise in water table and rise in soil salinity, which negatively affect crop production and farm income. This paper assessed the actual relationship between crop yields and field conditions, including water sufficiency, water table properties and salinity in the IIP project area. The study showed that the yields of summer season crops, maize and rice, are negatively affected by un-desirable conditions of water deficiency and salinity, whereby impact on maize is larger than on rice. In the winter season crops, wheat and sugar beet, yields have not been reduced by these field conditions. The crop most seriously affected by salinity at the downstream is maize and the second crop is rice, while sugar beet and wheat are tolerant to salinity and water deficiency. Also, water deficiency affected most the rice crop followed by maize, while sugar beet and wheat were tolerant to water deficiency. In future, it is necessary to check the present policy of contracting agriculture crops and its effect on cross-scale hydro dynamics of irrigation system management.

**Keywords:** Hydro-dynamics, Water productivity, Water supply, Water-table, Salinity.

## **Special Session 3: Restoration of Degraded Dry Ecosystems: beyond conventional approaches**

### **1. Aeolian desertification and its control in Northern China**

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Aeolian desertification is land degradation through wind erosion, mainly caused by excessive human activities. In the arid, semiarid and part of sub-humid regions in Northern China, Aeolian desertification has rapidly expanded in last 100 year and this is particularly true for last 60 year. The expansion of the desertified land has accelerated since 1950 as the annual expansion rate was 1560 km<sup>2</sup> between 1950 and 1975, 2100 km<sup>2</sup> between 1975 and 1988, 3600 km<sup>2</sup> from 1988 to 2000 and the recovery has been only - 1375 km<sup>2</sup> from 2000 to 2010. Thus the whole situation of aeolian desertification was deteriorating before 2000 and it has improved only after 2000. According to our studies, we believe that the human interventions can reverse the aeolian desertification based on the reasonable landuse and adopting varied prevention and curative measures. China has made much progress in understanding and combating aeolian desertification through many research and development efforts and projects for decades. The biggest project, based on a new state policy, is the National Project of 'Grain for Green Program', which started in 1997 and is covering 1060 counties in 22 provinces. The Program has adopted many approaches for combating the aeolian desertification to achieve its objectives: reclaim 3.67 million ha of farming land and degraded steppe, and rehabilitate 5.13 million ha of aeolian desertified land suited for reforestation and vegetation. There are about 8 million ha of land under the threats of aeolian desertification that will be brought under control in the next ten years and about 26.67 million ha of windbreaks will be planted. This paper is intended to analyze the process of aeolian desertification and to introduce the idea and approaches for combating aeolian desertification in Northern China.

**Keywords:** Aeolian desertification, Landuse, National project GGP, Policy and approach, Northern China

### **2. From degradation to sustainable management: policies for ground water use in dry ecosystems**

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The increasing population and food demand necessitates accelerated efforts to increase food production. This requires more land and water. Water scarcity has already been a reality in dry areas and particularly in the MENA region, which, with an annual

per capita availability of 1,200 m<sup>3</sup>, is one of the most water-scarce regions in the world. All available water resources are being utilized and the ground water is being over exploited leading to its irreversible depletion. Further, climate change is expected to make things worse. Agriculture is the largest user of water but its economic value added to water consumed is much lower than other sectors. On the other hand, farmers often over-irrigate with low farm water use efficiency. Therefore, policy makers and water resources managers are considering water reallocation options where agricultural share may be reduced. However, water pricing or valuation is a sensitive issue in that there is prevailing perception that Islamic Law guarantees free access to water as an essential element of life. The policy-makers are concerned about the negative effects of water pricing on farm income and the social stability. There is also the perception that water pricing will reduce food security. We analyzed the effects of structured and progressively increasing water tariffs on water saving, farm income and food production using two cases: Jordan and Syria. The findings indicate that it is possible to design specific tariffs that meet the challenges indicated above. First, farmers are given, without charge or at a low tariff, volume of water equivalent to the technical crop water requirement or profit maximizing water level. Then the tariffs are progressively increased for higher ground water withdrawals. In the case of Jordan we tested the application of 0.01 JD/m<sup>3</sup> at abstraction rate of 15,000-200,000 m<sup>3</sup>/well/year, and 0.1 JD/m<sup>3</sup> for abstractions exceeding 200,000 m<sup>3</sup>/well/year. In Syria, we tested the tariff of US\$1 for every 1 m<sup>3</sup> of irrigation water applied to the wheat crop in excess of 1,800 m<sup>3</sup> (the upper limit of the recommended application range). In all cases, the analysis indicates that these tariffs can change farmers' behavior towards ground water use by persuading them to adopt water conserving practices. These changes will have no or small negative effect if any on farm income, and in some cases even small positive effect, as a result of cost reduction and increased efficiency. In all cases, there is no significant reduction in food production due to reduced water application. This provides policy makers starting point to address the problem of water pricing in agriculture and increase the overall efficiency of water use across the whole economy as water scarcity will continue to worsen in the future.

**Keywords:** Water scarcity, Groundwater, Water pricing, Policy options, Farm income, Food production, MENA region

### **3. Revegetation of a degraded ecosystem in dry environments: Experiences from China**

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Dry ecosystems occupy over 40% of the earth's land surface and are subject to continuous degradation. Revegetation is difficult, if possible at all, due to poor natural resources and management of fragile ecosystems. It is therefore vital that revegetation includes the introduction of improved plants species and enhanced soil microbiological input.

In China, 2,620,000 km<sup>2</sup> (27.3% of China's land area) is degraded and the most important cause is wind erosion. Kubuqi desert is a sandy ecosystem located in Inner Mongolia, China. In this ecosystem, sand fixation through vegetation is practiced where the establishment of trees is the key issue. In order to improve the establishment, selection of tree species was conducted based on ecophysiological features of plants. Mycorrhizal fungi were tested to use for evaluation of the effectiveness. Mycorrhizal fungi form mycorrhizas in plant roots and develop mutualistic relationship with host plants to enhance plant water and nutrient uptake, drought and salt tolerance, and disease resistance. The association also leads to improved soil aggregation. Because of these functions, the use of mycorrhizal fungi appears to be effective for restoration of degraded drylands. But its application for the revegetation in drylands is still limited. As the result of our research on tree species selection, *Populus simonii* and *Salix psammophila* showed higher tolerance to drought and sand cover than other species. Inoculation of soil with mycorrhizal fungi enhanced the growth of *Pinus tabulaeformis*. In this paper, a case study on the revegetation of a sandy dry ecosystem in China will be introduced and the lessons learnt from this research will be discussed.

**Keywords:** Degraded lands, Revegetation, Kubuki desert, Mycorrhizal fungi, Sand and drought tolerant trees

#### **4. Dry ecosystem services: Approaches for valuation and ensuring public support**

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Humans derive a wide range of services from the natural capital, called ecosystem services, which make human life possible. Changes to ecosystems and degradation of ecosystem services, especially in the dry areas, are increasing at an alarming rate. Payments for Ecosystem Services (PES) is a novel conservation approach that internalizes environmental externalities through the creation of markets and quasi-markets. Private actors are assumed to put in practice the Coase theorem, meaning that the problem of externalities can best be overcome through private negotiations between affected parties. Dry ecosystems are home to some of the most charismatic species, support high species endemism and comprise many unique ecosystems and biomes, including savannahs, dry forest, coastal areas and deserts. However, currently dry ecosystems are neglected, under-valued and increasingly degraded. In order to restore the degrading dry ecosystems and to maintain the levels of ecosystem services derived from them, their true market value needs to be estimated so an action plan, which links the restoration to the beneficiaries, can be developed, funded and implemented. Two case studies, one from Mexico and the other from Kazakhstan, are presented to show how PES

plans can be developed with the participation of stakeholders. This involves identification of the ES, estimation of its value, mapping of beneficiaries of the ES and development of mechanisms that link the ES with the beneficiaries for its sustainable management. Decision- and policy-makers in dry areas can take cues from PES studies to better target taxes, penalties and subsidies, and create enabling policies, institutions and environment for saving and rehabilitating degrading ecosystems.

**Keywords:** Dry ecosystems, Degradation, Ecosystem services, Market value, Stakeholder participation, Enabling policies

## **5. Dust storms from degraded drylands of Asia: dynamics and health impacts**

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Asian dust is an atmospheric phenomenon where huge amount of fine soil particles are blown up by strong wind accompanied by a passage of cold front (i.e. dust storm). Dust initiated in the Chinese and Mongolian deserts often travels to downwind regions such as Korea and Japan, and is observed there as dust haze. Dust particles are often contaminated with air pollutants derived from human activities as they transport over densely populated regions. The frequency of dust events has increased in 2000s due to land degradations in emission regions. With the increase of dust event, concerns have been expressed over health hazards associated with dust. The main damages resulting from dust differ between emission region and downwind region. In emission region, it is a disaster that may cause death to people and animals. Also, highly dense dust there is an air pollution causing respiratory diseases and severe subjective symptoms. In downwind region, although the dust density is lower than in emission region, recent epidemiological studies have shown that Asian dust events coincided with increases in daily admissions and clinical visits for allergic diseases such as asthma, allergic rhinitis, and conjunctivitis. Moreover, it is pointed out that Asian dust leads to the development in healthy subjects of such symptoms as itchy eye and skin, nasal congestion, and sore throat.

**Keywords:** Asian dust, Air pollution, Health impacts, Epidemiological studies

## **6. Role of rainwater harvesting in the restoration of the Badia of Jordan and Syria**

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The agro-pastoral systems in eastern Mediterranean region (Jordan and Syria), called locally *badia*, is a typical degraded dry ecosystem. The *badia* forms over 70% of Jordanian and 60% of Syrian territories and is a home to several million inhabitants depending mainly on raising sheep and goat. It receives an annual rainfall of 100-250 mm in winter, from December to March, of which about 90% is usually lost to evaporation or quality deterioration in salt sinks. Summers are hot and dry with temperatures exceeding 40°C. Due to overgrazing, wood cutting, drought and rainfall characteristics, together with human interventions, vegetation has been degraded and soil erosion, by both water and wind, has continued over years. As a result, the dust storms have become frequent and there is continuous migration of people to cities. Now the *badia* is severely degraded providing only about 1-2 months of animal feed, depending on the annual rainfall, for the sheep and goats whose number exceeds the carrying capacity of the ecosystem.

ICARDA, with national and international partners, has conducted a research program for the rehabilitation of the *badia* in Syria and Jordan based on integrating water harvesting in the system revegetation. An 8-year 'Badia Water Benchmarks Project' led to the development of an integrated mechanized micro catchments water-harvesting package, along with the soil-water-plant and management components, suitable for this environment. Community based integrated watershed management approach with focus on water harvesting was used in the development. The 'Vallerani' machine was adapted to the *badia* environment and a laser guiding system was added for more precision and lower cost. The package was adopted by the national institutions in Jordan and development efforts are underway implementing it in the *badia* on a large scale. This presentation will highlight the main research outputs and the lessons learned in the out scaling and subsequent dissemination.

**Keywords:** Agro-pastoral systems, Badia of Jordan & Syria, Water harvesting, 'Vallerani' machine, Integrated watershed management

## Presentations in concurrent sessions

### **Theme 1. Application of new technologies for the improvement of stress (drought, heat, cold and salinity) resistance of crops for dry areas**

#### **1. Wheat breeding for multiple stress tolerance at ICARDA: Achievements and prospects**

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Wheat is the principal food crop in Central and West Asia and North Africa (CWANA) region with average consumption of 200 kg/capita/year. The productivity of wheat in the region is very low (2.5 t/ha) principally due to drought, heat and stripe rust among other factors. In the year 2050, the CWANA population is expected to increase from the current 0.9 billion to 1.4 billion, and the demand for wheat will rise from the present 164 million tons to 268 million tons. Fulfilling this demand is challenging especially in the face of climate change the effects of which are predicted to be more pronounced in the CWANA region. The wheat breeding program at ICARDA has developed high yielding wheat genotypes with increased water-use efficiency, heat tolerance and resistance to major diseases and pests following inter-countries shuttle breeding and key-location testing approaches. Some of the elite genotypes performed up to 2.5 and 11 t/ha under drought (250-300 mm seasonal rainfall) and irrigated/optimum moisture (550 mm seasonal rainfall) conditions, respectively. Major genes for resistance to stem rust and yellow rust have been deployed. Most of the elite genotypes have protein levels ranging from 12 to 16% with the 5+10 (Glu-D1), 7+8 (Glu-B1) and 2\* (Glu-A1) alleles. Molecular markers linked to heat tolerance and yellow rust resistances have been identified. Pedigree analysis showed that resistance sources for heat and drought in such elite germplasm were introgressed from synthetic wheats and wild relatives mainly *T. dicoccoides*. These genotypes have been distributed to the NARS for potential direct release and/or parentage purposes. Rapid deployment of such wheat varieties with improved crop management technologies will help to increase and enhance sustainable wheat production across the CWANA region.

**Keywords:** Wheat productivity, Drought, Heat stress, Stem rust, Yellow rust

## 2. Genome wide association study of adaptive traits under high temperature environments

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Heat stress has become a major threat to international food security in bread wheat (*Triticum aestivum* L.). Genetic variation for heat tolerance adaptive traits is limited in elite wheat germplasm, whereas in the primary gene pool, considerable genetic variability for heat tolerance has been found in both *Aegilops tauschii* and *T. turgidum*. Recently Multiple Synthetic Derivatives (MSD) population possessing large variation of *Ae. tauschii* has been developed. This study aimed to identify QTLs/genes associated with heat stress adaptive traits. We conducted a genome-wide association study (GWAS) using 15,616 DArT-seq and SNPs markers across 400 MSD population lines. Phenotyping was carried out under heat stress in Sudan at three locations. The 400 lines showed considerable genetic variation in most of the traits studied. Several lines were earlier than the check cultivar ‘Norin 61’ and others showed low canopy temperature. Three QTLs were identified for days to heading on chromosomes 2A, 2B and 2D. Two QTLs were detected for growth habit on chromosomes 2D and 5D. Two QTLs were identified for canopy temperature at heading stage on chromosomes 2A and 2D. In days to heading trait, the associated genes were the photoperiod alleles *Ppd-A1*, *B1* and *D1*. The variation observed and QTLs were detected in this population could be useful for wheat breeding and improvement for heat stress tolerance. On the other hand, this population could be evaluated for other abiotic stresses such as salinity and drought.

**Keywords:** Wheat, Heat stress, QTLs, Multiple Synthetic Derivatives (MSD)

## 3. Increasing wheat productivity under heat stress conditions through utilization of wild relatives cytoplasms

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The increase in wheat production after the green revolution was more due to improvements in harvest index than increased biomass. However, further substantial increase in harvest index is not expected. On the other hand, an opportunity exists for further increase in productive biomass and grain yield. It has been reported that a small

increase in photosynthesis rate will lead to considerable increase in biomass and hence grain yield. Increasing photosynthesis rate can be achieved by replacing wheat Rubisco with that from other species with different kinetic properties. This study aimed to examine the effect of wild species plasmon on wheat tolerance and productivity under heat stress conditions. We used 12 cytoplasmic substitution lines (CSL) and imposed the heat stress in a growth chamber (33/28°C day/night temperature) at seedling stage. The CSL varied in their response to heat stress. After three days of high-temperature treatment, CSL3, CSL4, CSL8 and CSL12 showed significantly higher photosynthesis compared to wheat background parent CS, whereas their stomatal conductance, transpiration and intercellular CO<sub>2</sub> remained equivalent to that of CS. CSL13 had the lowest photosynthesis rate under heat stress indicating the negative impact of its plasmon. The photosynthesis of CS reduced by 19% due to heat stress, whereas that of CSL3 and CSL4 were reduced by 4 and 12%, respectively. C12 did not show any reduction in photosynthesis rate due to heat stress. After 6, 9 and 22 days of heat stress only lines CSL3, CSL4 and CSL8 had maintained higher photosynthesis than the parent CS. CSL13 had delayed flowering, whereas CSL4 and CSL8 showed no sterile pollens with heat stress. The impact of these wild plasmons in wheat breeding and yield improvement under heat stress conditions is discussed in this paper.

**Keywords:** Wild species plasmon, Wheat breeding, Resistance to heat, Photosynthesis

#### **4. Biosafety considerations in the development of drought tolerant and insect protected maize under the Water Efficient Maize for Africa project in Kenya**

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Kenyans are among the 300 million people that are affected by the recurrent droughts in Africa, and suffer losses of 13.5% of maize grain yield to stem borer insect pests. Maize weakened by drought stress suffers more damage from stem borers. The Water Efficient Maize for Africa (WEMA) project is a 5-country multi-institutional initiative to address drought and insect pests in maize, with the objective to increase yields by 20-35% under moderate drought, and to reduce yield losses due to stem borers using both conventional and recombinant DNA techniques. A drought tolerance CspB gene from *Bacillus subtilis*, and an insect resistance gene from *Bacillus thuringiensis* (Bt) for stem borer pest control have been introduced to elite maize germplasm. The WEMA project has an internal biosafety strategy to ensure compliance with biosafety regulations set by

the National Biosafety Authority (NBA) that regulates handling, research, development and commercialization of genetically modified organisms (GMOs) in line with the Kenya Biosafety Law 2009. WEMA project developed biosafety facilities that meet international and national standards including a biosafety level II laboratory and greenhouse at Kabete and a confined field trial (CFT) site at Kiboko. WEMA has trained own personnel and has contributed to biosafety compliance trainings for policy makers, local administrators, scientists, technicians and regulators on the management of GM research facilities and materials. While ensuring the set standard operating procedures for handling the GM maize, WEMA has made two applications and obtained three approvals and notifications and five plant import permits for testing DT and Bt maize in Kenya. The WEMA project has also grown one insect protected maize and four drought tolerant CFTs in compliance with all biosafety regulations. Details on the achievements, challenges encountered, and lessons learnt during research and development for drought tolerant and insect protected maize in Kenya will be discussed.

**Keywords:** Bt maize, Drought tolerance, Stem borers, Water Efficient Maize for Africa (WEMA)

## **5. Flowering and fruiting of some new Valencia orange cultivars budded on sour orange and Volkamer lemon rootstocks**

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A field experiment was carried out in a private orchard at Wady El-mollak, El Sharqia Governorate, Egypt during two successive seasons (2012 and 2013) to evaluate flowering, fruit set, yield, fruit quality and develop relationship of temperature and humidity with fruit drop for some newly introduced Valencia orange cultivars. The experiment comprised five Valencia orange cultivars ('Frost', 'Olinda', 'Delta', 'Campbell' and '26') budded on sour orange (SO) and Volkamer lemon (VL) rootstocks, which were laid out in a randomized complete block design. Regarding the effect of cultivars, results showed that 26, Campbell and Frost gave the highest yield per tree. Whereas, TSS/acid ratio and Vitamin C content were not affected significantly by cultivars except Frost gave the lowest values of Vitamin C. Regarding the effect of rootstocks, VL rootstock gave the highest significant values of yield per tree, TSS/acid ratio and Vitamin C. Whereas the combination of cultivars 26, Delta and Olinda on VL rootstock gave the highest values of yield per tree with the highest values of fruit physical properties. Concerning the relationship between meteorological conditions (temperature and humidity) with fruit drop it was found to be a positive and strong with temperature. The relationship between humidity and fruit drop was negative and strong.

**Keywords:** Fruit quality, New Valencia orange cultivars, Sour orange, Volkamer Lemon, Yield

## **6. Effect of nano-calcium and nano-silicon compounds on salinity tolerance for green bean plants**

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Salinity is a major limiting factor for crop growth and productivity, especially in arid and semi-arid lands. Therefore, this study was conducted to find out the effect of applying nano-silicon and nano-calcium on mitigating the negative effects of salinity on green bean (*Phaseolus vulgaris* var. Polista). Seeds were planted in September 2013 and 2014 in pots containing sandy soil, and irrigated with saline water with a salt content of 500, 1000 and 1500 ppm. Nano-silicon was supplied at the concentrations of 1 cm<sup>3</sup>/l and 2 cm<sup>3</sup>/l and nano-calcium at 0.5 g / l and 1 g / l. Application took place at 2, 5, 7 and 9 weeks after planting. Data showed that plant height, number of leaves, and fresh and dry weights were improved under all doses of nano-silicon and nano-calcium compared to non treated control plants. Yield parameters followed also the same trend. Amongst various treatments, nano-silicon concentration of 2 cm<sup>3</sup>/l and nano-calcium dose of 1 g / l recorded the highest significant effect in mitigating the negative effects of salinity. It could be concluded that nano-silicon and nano-calcium are effective and efficient in mitigating salinity stress in green bean plants.

**Keywords:** Green bean, Growth, Yield, Salinity tolerance, Nano-silicon, Nano-calcium

## **7. Towards high quality seed production of corn under predicted water scarcity in Egypt**

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Egyptian agriculture is facing great challenges of food and feed production due to many constraints on crop production during the past few decades, mainly through the detrimental effects of drought and heat stress. These two factors greatly affect crop growth and consequently reduce crop productivity. In addition, limited sources of irrigation water available to Egypt and rapid increase of Egypt's population necessitate taking steps towards securing food production. Corn is among the food cereals that are greatly affected by water deficit and heat stress. Egypt grows about 920,000 ha of corn annually with an average yield of 8.16 t ha<sup>-1</sup> resulting in a total production of about 7.5 million t. Of this, 1.5 million t is yellow corn, which accounts for no more than 17% of the annual demand of yellow corn. Consequently, the first Executive 3-Year Plan 2018 of the Ministerial overall Strategy 2030 encourages expansion of area under yellow

corn to reach 830,000 ha, on the expense of some areas under white corn and low-productivity rice. To overcome the problems of water deficit and heat stress in yellow corn, several approaches can be pursued. Presently, breeding program of the National Corn Program (NMP) – in response to the envisaged climatic changes – is oriented to: 1) develop corn hybrids tolerant to drought and heat stress that can help in obtaining high yields with less water, and 2) develop early-maturing corn hybrids, which can save about 15% of water required for corn production. Additionally, the agronomy component of NMP focuses on developing packages of practices for newly released hybrids, besides the introduction of modern irrigation systems (drip and sprinkler) that help in utilizing the limited water resources more efficiently. The other significant component of NMP is producing high-quality seed of released hybrids, as high-quality seed plays very crucial role in increasing productivity and total corn production to bridge the gap between the domestic production and the annual consumption. Finally, providing corn growers with seeds of newly released hybrids is achieved through the fourth component of NMP, the Technology Transfer, in co-operation with the Central Administration of Agricultural Extension, through demonstrations on farmers' fields, adopting recommendation package of production practices.

**Keywords:** Yellow maize, Hybrid cultivars, Drought tolerance, National Corn Program, Production package

## **8. Current status of wheat production in Egypt**

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Historically, wheat yield in Egypt increased gradually over the past seven decades. Wheat total annual production increased from 1.3 million ton in 1950 to about 9 million ton in 2015. However, the production was not able to keep up with the rapidly growing population of the country, whose rate reached 1.8 million /year in 2015. The annual per capita consumption of wheat in Egypt has been estimated to be 180 kg/year, which places it among the top 10% of the wheat consuming countries in the world. This resulted in widening the gap between domestic wheat production and consumption (9 vs. 15 million /ton) in 2015. Therefore, increasing wheat production is an important national goal to reduce the amount of wheat imports, to save foreign currency and provide food security for the Egyptian people. To face these challenges, vigorous efforts within the wheat research program were directed to improve the genetic potential of new wheat cultivars, develop new production package and introduce wheat into new areas. Within the framework of the 2030 Sustainable Agricultural Development Strategy, Agricultural Development Executive Plan 2014/2015 - 2017/2018, it is expected that the current level

of wheat self sufficiency, 55-60%, would reach to 74% by 2018 and 85% by 2030. In the last five wheat seasons a great effort was made to increase wheat production through the Wheat National Campaign (WNC) which started in 2011/2012 season with 1257 demonstration plots in 14 wheat major production governorates and reached to 3411 demonstration plots in 2015/2016 season in 24 governorates. The direct impact of this campaign was the increase of the amount of wheat sold to the government; it reached a record 5.3 million ton in 2013/2014 season which is equivalent to 60% of the wheat required for making the subsidized bread (9 million ton). If this trend continued, achieving the goal of 74% self- sufficiency by 2017/2018 would be feasible.

**Keyword:** Wheat National Campaign, Wheat improvement, Production technology, Self-sufficiency in wheat

## **Theme 2. Sustainable management of scarce water resources**

### **1. Water harvesting in the drylands of North Africa: Opportunities and challenges**

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Due to its position between the Saharan desert and the Mediterranean Sea the North African region is mainly characterized by its variable rainfall and the recurrence of droughts. For centuries, the rainfed agriculture was mainly supported by the various traditional water harvesting techniques (WHT) developed by the local population as a form of adaptation with the specific ecological conditions of the region. During the last decades, new WHT have been also introduced in order to make the most use of the scarce rainfall water. However, the recent global changes and climate trends are putting new challenges on the rainfed systems in this region, and particularly the WHT in terms of effectiveness and adaptation. The paper discusses these issues.

**Keywords:** Drought, Traditional water harvesting techniques, Rainfed agriculture

### **2. Coping with the water scarcity issues through improving water productivity: the case of the irrigated cereal activity in Tunisia**

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Within the context of climate change and increasing water scarcity, the development of irrigated agriculture is required as main lever in order to deal with the food challenges. Tunisia is facing an imminent risk of water shortage given that the policy of the water supply reached its limit while the current water availability is already below the poverty line (450m<sup>3</sup>/capita/year). The irrigated agriculture consumes 80% of the available water and therefore it remains the main sector that might provide water saving for the other sectors. However, the irrigated agriculture should achieve optimum yields in order to increase production and to meet the population needs. The irrigated cereal crops, which account for only 7% of the total cereal area, contributed 25% of the total cereal production. However, the yields achieved are far from the expected potential level. This reveals a crucial question regarding the productivity and the efficient use of the water resources. In order to deal with this issue, field surveys were carried out among a sample of 130 farmers in the governorates of Beja and Siliana by addressing the farming system during the cropping year of 2013-2014. By using two-step nonparametric approach, the optimal production of the durum wheat crop was estimated in order to assess the

importance of the production deviation and to identify possible alternatives for improvement. The results showed that the water productivity is under the expected potential given that the average of the sample productivity reached only 8 kg/ha/mm. The estimated production frontier suggests that the durum wheat production could be increased by 28% by mastering perfectly the technology process. The results showed also that this improvement is plausible especially among farmers with a secondary education level and above. Moreover, farmers might reach better production among large size plots and by practicing suitable crop rotation.

**Keywords:** Water scarcity, Durum wheat, Water productivity

### **3. Improvement of rain water productivity of wheat by supplemental irrigation and advanced agronomic scenarios in upper Karkheh River Basin**

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In order to evaluate the role of supplemental irrigation and agronomic management scenarios on improving yield and rain water productivity of wheat, an onfarm study was conducted at multiple farms of Honam (Lorestan Province) in the upper Karkheh River Basin (KRB), Iran. The calibrated and validated AquaCrop model was used to define the best management scenario in order to enhance yield and water productivity (WP) of rainfed wheat during the 2013-2014 cropping season. As the next step, the best management scenarios analysis was carried out in wheat fields of three farmers. The applied treatments included two agronomic management (control and advanced management) and two water application management (rainfed and single irrigation) levels. According to the best scenario of AquaCrop model, single irrigation with depth of 60 mm was applied in spring at one of the three stages (at the first, middle and end of flowering period). Advance management was based on land preparation, fertilizer application management based on soil fertility analysis, and improved variety of wheat. The result showed that under rainfed conditions, advanced management increased rainwater productivity of wheat by 36% as compared to control management. The single irrigation application during flowering stage increased the wheat water productivity to 0.70 kg m<sup>-3</sup>, which is 74% higher as compared to control. The optimum program was obtained by a combination of advanced agronomic management package and single irrigation of 60 mm at the middle of flowering stage. This scenario increased the yield and rain water productivity to 176 and 134%, respectively as compared to control

management. Results of field experiments was in good agreement with the proposed scenarios by AquaCrop model. This work was supported by ICARDA.

**Keywords:** Rainwater productivity, Wheat, AquaCrop Model, Supplemental irrigation

#### **4. Deficit irrigation optimization for improving water productivity of sugar beet with AquaCrop: A case study of southern Urmia Lake basin**

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Urmia lake is faced with the serious water shortage in recent years. The ever-increasing demand and competition for the finite water resource call for more efficient use of water in all sectors, including the all-important agricultural food production sector. Deficit irrigation is important to reduce agricultural water use in areas where water is a limited resource. Development of sugar industry in this region and high irrigation requirement of sugar beet are causing depletion of water resources of Urmia lake. In this work we tried using AquaCrop model for optimization of water use in sugar beet farms under deficit irrigation strategies in order to improving water productivity and decreasing water use per unit area. The model requires data such as weather, soil, area, vegetation and crops and irrigation management parameters as input data. These were collected. After considering the sensitivity analysis the model was calibrated and validated on the basis of past results. To generate the yield response to variations in irrigation water, we used the FAO crop water productivity (WP) model, AquaCrop. Model calibration and validation, using experiments conducted in the region, showed that AquaCrop adequately simulated the yield response to different levels of irrigation water. The correlation coefficient between the predicted and actually realized root yield was 0.91. The model was then used to determine the yield-available water functions for different scenarios, assuming the best deficit irrigation (DI) strategy. An economic optimization procedure showed that maximum profits occurred at 20% deficit irrigation. The maximum and minimum yield was obtained from plots irrigated with full requirement at 7- day interval and 50 % of full requirement at 14- day interval, respectively. The highest water use efficiency (WUE) was about 11.6 and water productivity index (WP1) was about 8.4 from irrigations at 7- day interval and 50 % of required water. This means that it resulted in 34 % of water saving as compared to full irrigation at same interval. Full irrigation at 14-day intervals resulted in slightly lower WUE of 8.0. Considering WP, and the need to manage all the farm lands at present, meeting 50% of the irrigation needs of high management farming, we recommend an irrigation interval of 10 days with 75-80% water of that needed to meet the complete requirement of plants (or 20-25% deficit irrigation)

for southern Urmia lake region. In this way, with 29% reduction in water use there was only 23.5% and 16.0% reduction in the yield of beet roots and available sugar, respectively.

**Keywords:** Sugar beet, Water productivity, AquaCrop Model, Urmia lake

## **5. Impact of technology on sustainable water resource management on farm scale**

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The competition for existing freshwater supplies will require a paradigm shift from maximizing productivity per unit of land area to maximizing productivity per unit of water consumed in agricultural sector. This shift will, in turn, demand broad systems approaches that physically and biologically optimize irrigation relative to water delivery and application schemes, rainfall, critical growth stages, soil fertility, location, and weather. With low water use efficiency in irrigated agriculture, irrigation practices can be blamed for a lot of water loss. There are many practices and technologies that, if used, can significantly reduce the impact of agricultural activities on water resources. It is important to acknowledge that many technologies have already been developed and applied to various crops. For example, real time soil moisture and weather monitoring are emerging technologies that can potentially help improve the scheduling of irrigation. Irrigation systems that distribute water more efficiently along the farm and give higher water use efficiency such as drip irrigation can be more expensive to install, but they can also be 33 to 40 percent more efficient, carrying water or fertilizers directly to plants' roots. Subsurface drip irrigation (SDI) is a new technology within the irrigation systems that has progressed because the efforts of researchers and has become an accepted method of irrigation of both perennial and annual crops, making the use of water more efficient at the farm scale. The SDI technique is now being used throughout the world on a wide range of grain, forage and fiber crops including alfalfa, corn, cotton, soybeans and sugarcane. It is assumed that SDI could decrease the water evaporation from the soil surface compared to the surface drip irrigation. This study was aimed to review and evaluate the advantages of SDI compared to surface drip irrigation based on irrigation water applied to the farm. The results showed that soil evaporation decreased in early crop growth stages before soil surface was covered by crop. Simultaneously crop water productivity also increased.

**Keywords:** Irrigation technology, Subsurface drip irrigation, Sustainable water resource

## 6. Rainfall fluctuation at the central dry zone, Myanmar

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Annual rainfall of the central semi-arid zone of Myanmar is about 600 mm and the coefficient of variation is 0.25. Seasonal and inter-annual fluctuations are common. The wet season is separated into two periods, the early monsoon (May – June) and the late monsoon (August – October). Correlation between inter-annual time series of the early and the late monsoon is not significant ( $r = -0.25$ ). There is no remarkable correlation of inter-annual time series of the early monsoon with Southern Oscillation Index (SOI), North Atlantic Oscillation (NAO) and Arctic Oscillation (AO). On the other hand, there are significant correlations of the late monsoon with SOI at lag 0 – 5 months and with NAO and AO at lag 7 – 10 months. It is expected that there are tele-connections of the late monsoon with the Pacific Ocean at lag 0 – 5 month and with the Atlantic Ocean at lag 7 – 10 months. Regarding the correlations of inter-annual time series of the early and late monsoon with Global Sea Surface Temperature (GSST), there are significant correlations of the early monsoon on the Pacific and Indian Ocean and those of the late monsoon on the Pacific and Atlantic Ocean. The sea area on the Pacific Ocean of the significant correlations with the early monsoon is different from that with the late monsoon. Anomaly time series of the spatial averaged SST value over the significant correlated sea area indicates significant correlations with anomaly time series of the early and late monsoon (at the significance level  $<0.01$ ). Time series of SST difference between the positive and negative correlated areas of dipole (positive – negative) indicates stronger correlations with the original time series of the monsoon rainfall ( $|r|>0.6$ ).

**Keywords:** Inter-annual rainfall fluctuations, Southern Oscillation Index, North Atlantic Oscillation, Global Sea Surface Temperature, Monsoon

## 7. Characteristics of individual rainfall events and its dependency on the minimum inter-event time in a dry desert area in north China

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The intensity and duration of rainfall event are critical for the infiltration processes and soil moisture replenishment in water-limited ecosystems. What is more, the rainfall event timing and magnitude are important drivers of ecosystem processes and are instrumental in creating landscape heterogeneity in arid regions. To better characterize the individual rainfall events in a dry desert area, a pluviograph record of rainfall processes was analyzed between the year of 2008 and 2015 from Shapotou in the Tengger Desert, China. Results show changing the minimum inter-event time (MIT) alters the number of rainfall events remarkably, the mean rainfall rate declines and the geometric mean event duration rises. The number of rainfall events, the mean rainfall rate, and the geometric mean event duration differed under different criteria of individual rainfall depth (e.g., 0.1, 0.5, 1.0, 5.0 mm), except that for an individual rainfall depth of 0.5, 1.0, and 5.0 mm, the features (the number of rainfall events, the mean rainfall rate, and the geometric mean event duration) mentioned above are identical for MIT=2 and 3 h. Therefore, there is no need for further identification to set MIT at two or three hours in this specific arid desert area. This wide variation in the properties of rainfall events indicates that more attention needs to be paid to the selection and reporting of event criteria in studies of event-based infiltration process and soil water cycling. The selection of a MIT criterion is shown to involve a compromise between the independence of widely-spaced events and their increasingly variable intra-event characteristics.

**Keywords:** Water-limited ecosystems, Rainfall event, Rainwater infiltration, Soil water recycling

## **8. An overview of the GCC Unified Water Strategy 2016-2035**

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The Gulf Cooperation Council (GCC) Countries are situated in one of the most arid regions in the world, with extremely poor endowment of freshwater resources. Despite the water scarcity, the GCC countries have done well in providing water for their ever-increasing population and rapidly expanding economic base. However, this has been achieved only by resorting to relatively very expensive and costly investments in water supply sources and infrastructures manifested by desalination, water treatment, dams construction, as well as groundwater over-drafting. Being an important vector for socio-economic development, there is a need for an efficient and sustainable water management to ensure that the water sector can continue to serve the region's development needs.

However, currently the GCC countries are facing several major challenges that are threatening the water sector sustainability. These include increasing water scarcity, increasing costs for infrastructure and service delivery, resources deterioration, increasing environmental and economic externalities, and many others. The main driving forces of these challenges are population growth and changing consumption patterns, low supply efficiencies, lower rates of water reuse and recycling, and low energy efficiency in the water sector. The intensity of these challenges is expected to increase in the future due to the additional driving force of the impacts of climate change. Realizing these challenges, the GCC Supreme Council has issued in its 31<sup>st</sup> summit (2010) the directive of “*serious and speedy steps should be taken and endorsed by the GCC Supreme Council towards a long-term comprehensive Gulf water strategy*”. In 2016, a GCC Unified Water Strategy, 2016-2035 (GCC UWS) has been finalized by the GCC Secretariat General and recently approved by the GCC water ministers. This paper will present the main challenges facing the sustainability of the water sector in the GCC countries, the formulated GCC UWS (main themes and strategic objectives, and targets), the simulated financial, economic and environmental benefits resulting from its implementation, and its expected overall contribution to the water sector sustainability in the GCC countries.

**Keywords:** Gulf Cooperation Council, Water scarcity, Resource deterioration, Environmental benefits

### **Theme 3. Agronomic and crop improvement interventions for sustainably enhancing agricultural productivity of small-holder farmers in dry areas**

#### **1. Agronomic improvements can make future cereal systems in South Asia far more productive and result in a lower environmental footprint**

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South Asian countries will have to double their food production by 2050 while using resources more efficiently and minimizing environmental problems. Transformative management approaches and technology solutions will be required in the major grain-producing areas that provide the basis for future food and nutritional security. This study was conducted in four locations representing major food production systems of densely populated regions of South Asia. Novel production-scale research platforms were established to assess and optimize three futuristic cropping systems and management scenarios (S2, S3, S4) in comparison with current management (S1). With best agronomic management practices (BMPs), including conservation agriculture (CA) and cropping system diversification, the productivity of rice- and wheat-based cropping systems of South Asia increased substantially, whereas the global warming potential intensity (GWPI) decreased. Positive economic returns and less use of water, labor, nitrogen, and fossil fuel energy per unit food produced were achieved. In comparison with S1 scenario, S4, in which BMPs, CA and crop diversification were implemented in the most integrated manner, achieved 54% higher grain energy yield with a 104% increase in economic returns, 35% lower total water input, and a 43% lower GWPI. Conservation agriculture practices were most suitable for intensifying as well as diversifying wheat–rice rotations, but less so for rice–rice systems. This finding also highlights the need for characterizing areas suitable for CA and subsequent technology targeting. A comprehensive baseline dataset generated in this study will allow the prediction of extending benefits to a larger scale.

**Keywords:** Food production, Environmental protection, Cropping systems, Crop management practices

#### **2. Effect of irrigation intervals and antitranspirants on vegetative growth, fruit and seed yield of summer squash (*Cucurbita pepo* L.)**

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Strategies such as foliar application of antitranspirants show possibilities for conserving irrigation water and aiding plant survival under dry conditions. In this study, two field experiments were carried out during the summer seasons of 2012 and 2013 to

examine the response of summer squash (*Cucurbita pepo* L.) to the foliar application of three antitranspirants (Kaolin, K<sub>2</sub>SO<sub>4</sub> and CaCO<sub>3</sub>) plus control under three irrigation intervals (7, 11 or 15 days). The results indicated that the better plant growth vigor, heavier total yield, and better seed yield and quality were recorded when squash plants were irrigated at shorter interval (7 days interval). Foliar spray of different antitranspirants led to more growth vigor, more fruits yield as well as seed yield and quality compared with control plants and Kaolin was the best antitranspirant. Irrigating squash plants every 7 days and spraying with Kaolin resulted in best fruit and seed yields. It could be recommended that using antitranspirants as foliar application especially Kaolin is an effective tool in reducing the level of drought stress.

**Keywords:** Squash, Irrigation intervals, Drought stress, Antitranspirants, Yield

### **3. Determination of irrigation depths for potato using a process model and quantitative weather forecast**

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A field experiments was carried out to evaluate the effectiveness of a new scheme for determining irrigation depth using a numerical model of crop response to irrigation and quantitative weather forecast. Potato crop was grown in summer season of 2015 using a drip irrigation system at the Arid Land Research Center, Tottori, Japan. Two treatments were tested, automated irrigation (A) and proposed scheme (S), with two replicates for each. Irrigation interval was set at 2 days for treatment S, while for A treatment water was applied for 1 hour when water content at the depth of 15 cm became less than 0.09 m<sup>3</sup> m<sup>-3</sup>. Results indicated that predicted water content agreed well with observation. Proposed scheme (S) could save water by 9%, while yield was increased by 16%, resulting in higher net income as compared to A. These results reveal that proposed scheme can improve net return and save costs for equipment such as soil moisture probes, data loggers and solenoid valves.

**Keywords:** Irrigation, Potato, Water content of soil, Water saving

### **4. Use of biosensor for estimating abiotic stresses and technical management of the olive groves**

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Global climate changes will introduce major changes in the agricultural ecosystems, which will affect the agricultural productivity. Water stress is considered to be the most

important factor limiting plant growth and production, particularly in the dry areas. Thus, monitoring of plant water status in field-grown plants is of great interest. Changes in plant water status could be described by using a sensitive physiological indicator that integrates the soil and climatic conditions. The aim of our study was to evaluate a quantitative direct relationship of the olive tree water status, which is necessary for scheduling irrigation or management of olive plantation. The assessment techniques used is the magnetic leaf patch clamp pressure probe (LPCP probe) that allows us to monitor easily and continuously the leaf water turgor potential. The experiments were conducted in a hedgerow 4 ha olive orchard, which is located in Jemmel in the central-east part of Tunisia. The treatments were set up in the same plot on olive tree planted at a density of 69 trees ha<sup>-1</sup>. The aim was to observe the water status of olive trees with two different cultural conditions: T0: conventional supplemental irrigation (control) and T1: supplemental irrigation with a hydro-absorbent product injected into the soil. The results indicated that the instantaneous data provided by the technology of LPCP probe allowed us to detect precociously the water deficit and to have accurate information on the hydraulic behavior of the olive trees and the efficiency of hydro-absorbent product to enhance the management of the available water. Indeed, we found that the effect of the water made available to the olive trees by the hydro-absorbent is not instantaneous, as is the case of direct water supply, but has lag time of a few days.

**Keywords:** Water stress, Olive trees, Irrigation management, LPCP probe

## **5. Changes in essential oil yield and composition of dill (*Anethum graveolens* Linn.) in response to climate conditions**

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The increasing tendency toward herbal medicine for curing diseases makes the need to cultivate various medicinal plants inevitable, both at worldwide level and inside Egypt. Change in planting time leads to significant change in weather parameters and consequently the performance of the crop in oil accumulation in herbal medicinal plant. Two field experiments were carried out during the winter seasons of 2013/2014 and 2014/2015 to examine the response of dill (*Anethum graveolens* Linn.) to climate conditions for oil accumulation and composition under five sowing dates i.e. mid-November, end-November, mid-December, end-December, and mid-January. Results indicated that essential oil yield declined as planting date was delayed. Late planting times (end-December and mid-January) resulted in low oil yield in comparison to the early sowing dates and the essential oil percentages for different planting times were 3.53% (mid-November), 3.26% (end November), 2.65% (mid-December), 2.1% (end December) and 1.4% (mid-January). Generally, the major compounds of the essential oil

were also affected by different planting dates. It could be recommended that for high yields of dill oil, mid-November is the best sowing time under Mansoura conditions in Egypt and avoiding late sowing is crucial to producing high yield and quality of dill oil.

**Keywords:** Dill (*Anethum graveolens* Linn.), Essential oil, Yield, Sowing time

## **6. Carnation production using different soilless culture systems under protected cultivation in Egypt**

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The limited water resources are the major factor that drew the attention towards the use of intensive agriculture in arid land. Protected cultivation was the first step and in recent decades. Soilless culture has attracted more attention specially under conditions of aridity, water shortage, and the need for maximizing crop yield per square meter of soil as well as per cubic meter of water. Also, producing cut flowers, that are considered one of the cash crops, using soilless technology will help to maximizing the net profit of the agriculture sector. An experiment was, therefore, carried out in the experimental site of Arid Land Agricultural Services and Research Center (ALARC), Faculty of Agriculture, Ain Shams University under unheated plastic house during two successive seasons, 2007/2008 and 2008 /2009. The experiment aimed at determining the best soilless culture system for producing carnations with high yield and flower quality. Standard carnation '*Dianthus caryophyllus*' was used in this experiment. Carnation seedlings were planted in five soilless systems: Aeroponics (Aero.), Nutrient Film Technique (NFT), Shallow container (10 cm depth) filled with perlite (CA), Deep container (20 cm depth) filled with perlite (CB), and Horizontal bag filled with perlite (HB). Plant height, shoot and root fresh weight, number of flowers/m<sup>2</sup>, flower stem length, flower head diameter, flower weight, N, P, K % in the leaves and water use efficiency were recorded at various stages. The results showed that aeroponics system was the most suitable soilless system for producing carnations. Plants grown in aeroponics recorded the highest values for plant height, shoot and root fresh weights, number of flowers per m<sup>2</sup> and higher flowers quality measurements than the other tested soilless systems. Moreover, aeroponics recorded the highest water use efficiency and thus more flowers per drop of water.

**Keywords:** Carnation, Aeroponics, Hydroponics, Substrate culture, Water use efficiency

## **7. Enhancing climatic resilience of farming in arid regions of north-west India**

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Arid regions constitute 12% of total geographical area of India ranging from cold arid areas in northern parts to hot arid areas in western and southern parts of the country. Climatic stresses (drought, extreme temperatures, sand blasting), edaphic factors (sandy soil with low organic carbon content and poor water holding capacity), and relatively higher biotic pressure (human and livestock population) in these areas are major contributing factors to degradation of natural resources and lower productivity resulting in greater risk of farming *per se*. Enhancing stress resilience of farming system, therefore, remains a major challenge in these regions. Several interventions in crop management, water conservation, and alternate land use have been evaluated across diverse farming systems to mitigate effects of stresses on crops and livestock and to develop appropriate contingency plans to curtail the losses. Water harvesting, moisture conservation, and choice of water-efficient crops, cultivars and cropping system have been, and continue to be, key components to enhance water use efficiency and to achieve the objective of “more crop per drop”. Identification and utilization of stress-adapted crop germplasm has resulted in development of stress tolerant cultivars providing stable yields across a range of stress environment. Several models of integrated farming system have been developed with variable proportion of crops, horticulture, grasses, trees and shrubs in order to fulfil the need of food, fodder, fuel and fruits and to minimize the risk associated with farming in the arid regions. Upscaling of new technologies has met with variable success. The paper would discuss lessons learnt from past, challenges and future strategies to make farming in arid regions more profitable and resilient to climatic stress.

**Keywords:** Climate resilience, Cold and Hot arid regions, Farming systems, Stress tolerant cultivars

## **8. Vision on olive industry in Egypt**

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In exploiting deserts, plants which can thrive under desert conditions must be selected. Olive trees represent such plants and the crop is being grown under semiarid conditions of Egypt. Egypt produces about 16% of table olives in the world and its olive oil production accounts for 0.4% of the world production. In spite of the remarkable annual evolution in olive area since the eighties in Egypt there are still many challenges facing the production, processing and marketing of olives in Egypt. The challenge in

production is the lack of adequate technical knowhow about growing (fertilizer, water management, pruning etc.) olive trees. Most promising varieties for pickled green, black and dual purposes have to be identified and their mixing with the varieties used for oil is to be avoided. Suitable mechanization of inter-cultivation and harvesting specifically suited for table varieties of olives as contrasted to the oil varieties has to be developed. The post-harvest handling should be such that ensures best quality for both table and oil purposes. Added to these challenges is the challenge posed by the impact of climate changes on the productivity of some olive varieties as they have shown some deterioration in recent years. There is a need to map out the most important olive varieties suitable for each zone in the face of these changes. The modern processing knowhow that would ensure quality standards desired by the export market is also limited. There is a need for identifying these standards and to train human resources for contemporary processing to achieve these standards. There is also a need to enhance consumer awareness for improved quality within the country. Parallel with the chemical testing, specialized sensory testing is essential to determine and label the quality of the oil. The marketing poses another major challenge. There is a need to develop plans and strategies to create collective marketing opportunities, exploring the role of cooperatives in the development of olive cultivation, and enhancing the exchange of experiences through the establishment of channels of communication between different olive-producing areas, including the areas known for ancient olive production in Egypt (Siwa Oasis , Sinai) and having traditional knowledge to take advantage of the historical dimension of the place in the global product marketing. Creation of a National Council for the production of olives and establishment of a specialized institute for olives could help in overcoming these challenges.

**Keywords:** Desert plants, Table olives, Production technology, Post-harvest technology

## **Theme 4. Soil health and land use constraints for agricultural productivity in dry areas and their management**

### **1. Approaches for the integrated agriculture management of salt affected environments in marginal regions of the Middle East**

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Salinity is a major constraint to agriculture production, especially in the arid and semi-arid parts of the Middle East (ME) region where many of the groundwater-based agro-ecosystems and more than 25% of river-based irrigated agricultural lands are affected by salinity and waterlogging. Such areas in the region are also extremely vulnerable to climate change impact (in particular, drought and high temperatures). It is important to prevent further degradation of such agro-ecosystems and sustain the livelihood of farmers living in marginal conditions. The aim of this paper is to find proper approaches for alternative production and management systems that are appropriate to the socioeconomic and environmental conditions in the region. In order to succeed in utilizing marginal land and water resources, agricultural practices, inputs and management must be modified to meet the special peculiarity of agriculture under saline conditions. Therefore, the paper focuses on two main important approaches for the integrated agriculture management of salt affected marginal environments in ME region: 1- Enhance crop diversification through identifying climate resilient crop varieties and accessions that tolerate marginal and saline conditions, climate change impact and other factors restricting productivity. 2- Integrated Management Packages (IMP) for enhanced livestock production in marginal environments. Efforts to reduce animal feed costs would help to increase the profits of the production system and farm income. More information, methods and data concerning these approaches are presented in the paper. It is concluded that developing forage specialized farming systems based on salt-tolerant forages and marginal quality water can help to alleviate the climate change and salinity impacts. Such approaches and systems will help ameliorate feed scarcity in small scale crop-livestock farms in a sustainable manner and will contribute to the diversifying of on-farm production, expansion of farm enterprises, securing farmers' income and consequently improving farmer's livelihood.

**Keywords:** Salinity, Marginal lands, Crop diversification, Integrated management Package, Livestock production

## **2. Evaluation of soil quality under organic agriculture systems in irrigated arid lands**

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Evaluation of soil quality or soil health is complicated by many physical, chemical, and biological processes and their interactions in time, especially at different cultivation periods. The present work aims to study the effect of organic farming under different cultivation periods on soil quality indicators (i.e. physical, chemical and biological) in selected organic farms. The study sites were selected to represent different farms with different organic cultivation periods and different management practices. The selected sites represent two different great soil groups i.e. (torripasamment and torrerts). The principal component analysis (PCA) was used to obtain the minimum data set needed for soil quality evaluation. The PCA of the standardized values was used for the measured 27 soil variables for different periods of organic cultivation and the same for uncultivated soil. Results indicated that organic farming improved most of the studied soil quality indicators of both soil groups i.e. organic carbon content, CEC, bulk density, porosity, aggregation state, structure factor (Sf), soil salinity, available macro and micronutrients level, SAR, ESP%, total N (%NT), OM%, C/N ratio, soil respiration, microbial biomass (MBC), and microbial quotient (MQ). Results indicated that soil respiration, MBC, MQ, organic matter, and physical aspects of soil quality are the most sensitive indicators of soil quality evaluation. In torripasamment soil the score of Soil Quality Index (SQI) depended mainly on soil biological properties, but in torrerts soil the score of SQI depended on soil physical indicators. The best score for SQI was at the fourth cultivation periods in torripasamment (13 years organically managed) and at the third cultivation period in torrerts (17 years organically managed).

**Keywords:** Organic agriculture, Soil quality index, PCA, MDS, Soil organic matter, Arid lands.

## **3. Organic sources of nutrients as climate smart management strategies for soil temperature and moisture stresses for sustainable wheat production in drylands**

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Dry areas of the world mostly fall within highly fragile ecosystem threatened by climate changes. These areas are homes to a very large population which faces poverty and malnutrition. A great proportion of the people living in those environments depend to a large extent on the natural resources for their livelihoods. The demand for water in these areas is mainly caused by over exploitation of the resources together with unchecked water loss through evapo-transpiration and increased environmental temperatures. In view of that, a study was conducted in Kenya to evaluate the contribution of organic sources of fertility on soil temperature and moisture and wheat yields in wheat-potato cropping systems. Organic sources of fertility included farm yard manure (5 t ha<sup>-1</sup>) and biomass from agro-forestry tree (*Leucaena trichandra*) (2.5 t ha<sup>-1</sup>). Soil temperature and moisture were measured weekly using a Time Domain Reflectance (TDR) moisture metre. Data were subjected to an analysis of variance (ANOVA) using SAS statistical package. Farmyard manure (FYM) resulted in significant (P<0.05) increase in soil moisture accumulation and significantly lower soil temperature. Similar trend was also observed with the use of green manure. Overall wheat yields were significantly influenced by the application of organic source of soil fertility as opposed to inorganic source. These findings may provide useful strategies in the drylands for enhancing judicious use of the natural resources while ensuring sustainable management and increased wheat productivity in changing and variable climate.

**Keywords:** Organic fertilizers, Agro-forestry biomass, Soil moisture, Soil temperature

#### **4. Testing and up-scaling sustainable technologies for soil salinity reduction in Taveta irrigation schemes**

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Soil salinity is a challenge to land productivity in semi-arid Taveta irrigation schemes, where it affects over 54,000 farm families in over 800 hectares of land. Research was conducted from 2011 to 2014 to test and up-scale sustainable and affordable technologies for soil salinity management. The technologies tested were *Mavuno* NP fertilizer at 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>; 20 t ha<sup>-1</sup> farmyard manure (FYM) + *Mavuno* NP fertilizer at 60 kg P<sub>2</sub>O<sub>5</sub>.ha<sup>-1</sup>; 40 t ha<sup>-1</sup> crop residue incorporation; 100% gypsum requirement; Rhodes grass rotation; Sudan grass rotation; and farmer practice. The results showed that 20 t ha<sup>-1</sup> FYM + *Mavuno* NP fertilizer at 60 kg P<sub>2</sub>O<sub>5</sub>.ha<sup>-1</sup> was significantly (p ≤ 0.05) different from farmer practice and increased maize (*Zea mays* L.) yield. However,

this treatment was not significantly different from *Mavuno* NP fertilizer. Maize yields increased over time as the soils were cultivated with soil salinity-reduction technologies. After three seasons of planting, maize yield was significantly ( $p \leq 0.05$ ) increased by all treatments and more so in crop residue incorporation. It was concluded that 20 t ha<sup>-1</sup> FYM + *Mavuno* NP fertilizer at 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> can be recommended for use by farmers in saline-sodic soils of Taveta sub county and crop residue incorporation with *Mavuno* NP fertilizer at 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> is a suitable technology in the long run. These technologies are recommended for up-scaling in salt affected soils.

**Keywords:** Salinity management, Taveta irrigation schemes, Manure, *Mavuno* fertilizer, Crop residues

## 5. Impacts of land reclamation and urbanization on agriculture land use in Egypt

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Egypt has a total area of about one million Km<sup>2</sup> under arid to hyper arid climatic conditions. It is a densely populated country with more than 90 million inhabitants, mainly concentrated on a small territory (about 5%) around the Nile Valley and Delta with regional disparities. This has led to environmental problems causing serious public concern, particularly the encroachment on the old agricultural lands. Land reclamation and development is considered one of the solutions for alleviating these problems and more efforts are needed to better redistribute the population in promising desert areas. Data indicated that more than 3 million Feddans were reclaimed and developed since 1950. The study presents the land reclamation and development since 1952 till date and the future plans. Results of monitoring urbanization, using satellite data, for the Nile valley, Delta and fringes in 1985 to 2007 and 2007 to 2010 years indicated different land use changes during that period (i.e. agriculture, urban, traffic ways, water bodies including northern lakes and others). Results indicated that total agricultural areas increased while informal urbanization dominated the patterns of urbanization encroachment. It showed that urbanization denatured the unique alluvium soils and the annual agricultural land use loss was 31.0 thousand Feddan / year in the period 1985-2007. Also, the annual loss in the period from 2007-2010 was about 41.0 thousands Feddan/year. If this urbanization rate were to ceaselessly continuous, the integrated loss of the remaining cultivated soil will result in a catastrophic loss of the Nile alluvium soils. The study reflected also that careful new land expansion and development in the desert could be a solution for many of the serious environmental problems facing Egypt.

**Keywords:** Old agricultural land, Land degradation, Reclamation, Urbanization

## **6. Assessing the aftermath of informal irrigation practices under the arid climate east of Suez canal using Hyperion and multispectral remote sensing data**

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The study was conducted in El Qantrasharq District of Ismailia Governorate, east of Suez Canal, covering an area of almost 14355ha (34165feddans) as a representative of vast cultivated area in Egypt that is informally irrigated under arid climate. In this study, for getting more accurate mapping results, Hyperion (EO-1) and multispectral (TM8) remote sensing data were used, both acquired in January 2016. Normalized Difference Vegetation Index (NDVI) was extracted from the two types of data for mapping the land cover features. NDVI values of the cropped area with irrigated trees dominated by mango under slightly saline soils ranged from 0.22 to 0.43 by EO-1 but from 0.24 to 0.35 by TM8. For the annual cropped area with surface irrigated herbaceous crops dominated by clover in slightly saline soils, the values ranged from 0.44 to 0.53 by EO-1 but from 0.35 to 0.43 by TM8. The values of the waterlogged area with extremely saline soils ranged from 0.01 to 0.03 by EO-1, while by TM8 they ranged from 0.07 to 0.1. Pearson's Correlation between the processed NDVI values from TM8 and EO-1 was 0.89 (showing strong correlation). For setting up that correlation, the pixel values of TM8 were selected to fit the same sites as of spectral signatures of EO-1 that reflected within ranges of NDVI values. It is concluded that use of spectral data from TM8 within those adapted ranges can produce more valid and accurate results concerning the cultivated and deteriorated land. Also, these adapted NDVI values can be manipulated to serve an extrapolation process for later on scanning of other managed land. The frequent availability of TM8 data versus the scarcity and costs of other ones in order to monitor the land degradation within proper systemized dates is an added dvantage for the former.

**Keywords:** Land degradation, Land cover, Hyperion data, TM8, NDVI.

## **7. Rainfed agriculture impact on the hydrological system of Wadi El Raml in the North Western Coast, Egypt**

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As a result of the increasing demand for food and water, people tend to alter the land cover and soil in their surrounding environment. For instance, in the northwestern coast of Egypt tremendous reduction at the pastoral grazing lands has occurred in the last 60

years due to increasing livestock numbers, rain-fed agriculture expansion, and large urban development. One of the big challenges is to determine the impact of these changes on the biological processes associated with the land cover changes such as plant and animal biodiversity, the hydrological and geochemical processes. The hydrological processes are highly impacted by the land cover changes including the evapotranspiration, surface and subsurface flow, soil moisture and erosion. Rain-fed agriculture in the North Western Coast of Egypt provides the food security for the majority of the local Bedouins. As a result of the limited resources, local Bedouins alter their lands to move from rangelands to rain-fed agriculture. The downstream impact of changing land cover in the upstream of Wadi El Raml was simulated using the semi distributed KINEROS2 model. Three scenarios were tested which include, 1) converting the rangeland to rain-fed agriculture of winter crops including wheat and barley 2) converting the bare soil to rangelands assuming following rangeland restoration strategy 3) the base simulation which is the current situation of mixture between rangeland natural vegetation and rain-fed crops. Recent high resolution satellite imagery were acquired for the study area and used for distinguishing the land cover types dominating the study area. The supervised classification of the satellite image revealed that there are 5 major land cover classes; urban, orchard, rain-fed crops, rangeland and bare soil. The primarily results revealed that, changing the land cover type from rangelands to rain-fed agriculture increased the surface runoff by 1.14 to 17.69 %. Also, there was an increase in the sediment yield ranged from 13.96 to 26.83% when the land cover was completely changed from rangelands to rain-fed agriculture. These results combined with our field survey and experiences show that the current primitive methods of farming of barley, the extensive grazing of the wild plants by large herds of goats and sheep and by camels, and the indiscriminate cutting of woody plants for fuel have depleted the land of its natural wealth of vegetation and led to serious erosion of the soil. It is highly recommended that a limited area should be converted from rangelands to rain-fed agriculture and rangeland improvement and restoration strategy should take place for the conservation of these valuable ecosystems.

**Keywords:** Rainfed agriculture, Land cover classes, Satellite imagery, KINEROS2 model

## **8. Using information communication technologies in development and sustainable management of drylands**

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There are great potentials in developing dryland to help Egypt achieve food safety. Although ICT was sophisticated when introduced to Egyptian farmers 15 years ago in the

shape of a Virtual Extension and Research Communication Network (VERCON), it was very successful with farmers by the help of Extension Advisors (EA). VERCON was started in 2002 as an agriculture network, and based on its success, The Rural and Agricultural Development Communication Network (RADCON) was launched in 2006 to help the rural community. In spite of the financial and logistic problems, the Ministry of Agriculture was able to maintain its function until now and VERCON continues to be the second most visited agriculture network in Egypt. These networks also targeted newly reclaimed lands (Nubaria and Ismailia) and got more success than in the old lands because of the nature of farmers in these areas. In 2007, RADCON/VERCON covered 18 governorates and 96 extension centers all over Egypt. In the past 10 years, mobile phones were accepted and used by almost all farmers. Along with many new applications related to dryland development, RADCON/VERCON have the potentials, reputation and experiences to compete well with others in the agriculture knowledge dissemination field. Successful examples include: technical information system of reclaiming and using drylands, agricultural practices information systems, farm management decision support system, farm management expert systems, market information system, locust early warning systems, and tracking systems for clean products. RADCON was funded by the Italian/ Egyptian Debt Swap program and executed by Food and Agriculture Organization (FAO), and implemented by the Central Laboratory for Agricultural Expert Systems (CLAES) with Agricultural Extension & Rural Development Research Institute (AERDRI) and other stakeholders. RADCON consists of two types of modules. The first type focused on improving extension works through expert systems, grower problems, extension documents and intelligent search modules. Expert systems were used in different fields such as variety selection, irrigation and land preparation. 'Variety selection' expert system helps farmers in choosing the best variety according to different parameters such as soil type, water salinity, water quality and weather conditions. The 'Irrigation' expert system provides farmers not only with optimum quantity of water for irrigation but also a complete irrigation schedule including dates and method of irrigation according to parameters provided by farmers. 'Land preparation' expert systems provide the farmers with a list of preparation operations necessary for planting certain crops based on parameters fed by farmers. 'Grower Problems' expert system was developed to provide farmers, through extension officers, solutions to their field and livestock problems. Technical solutions of problems are the responsibility of research institutes and research stations in Agricultural Research Center. 'Extension Documents' system allows farmers to browse an extension document which will help them in managing their crop and livestock. Extension Documents Intelligent Search was developed to facilitate finding specific paragraphs related to agriculture question. The second type of RADCON modules focused on rural development through Women's corner, Youth, Marketing, NGOs, and Environment modules. 'Women's corner' module supports rural women with education, health and family affairs. Also, it informs them on a set of handicraft items

which they can make at home and help themselves in increasing their family income. 'Youth' module tries to solve the youth unemployment problem by improving their capacity and skills, and how they can start up their own work. 'Marketing' module provides agricultural stakeholders with adequate information on exporters, producers, growers, support services, marketing opportunities. Facilitating grower and producers cooperation is done through the 'NGOs' module. 'Environment' module helps in conserving natural resources and produce clean product. It provides information such as practices and recycling of waste .As a result of applying RADCON in 50 villages in 6 governorates, it has helped in improving both the extension agricultural advisory services and rural development.

**Keywords:** Information technology, Expert Systems, Rural development, Women empowerment

## **Theme 5. Soil erosion and desertification processes and control**

### **1. Key erodibility factors of dust emissions in the Gobi Desert – findings of the Project Asian Dust, Tottori University**

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Dust observations were carried out since March 2012 at Tsogt-Ovoo (TsO), Mongolia, in the northern Gobi Desert. An analysis of synoptic data shows the highest frequency of dust occurrence at TsO in East Asia. This suggests that TsO has huge dust sources. Earlier research, using synoptic data, indicated narrow seasonal variations of a threshold wind speed of dust occurrence (TWS) in desert regions including the Gobi Desert. In addition, one can expect that with low precipitation and limited vegetation cover, a narrow seasonal variation of TWS at TsO would exist. However, we found a clear seasonal variation of it. This suggests an aeolian erodibility factor at TsO that strongly control TWS. Drastic changes in TWS were reported from the data of our observation, discussing roles of soil crust and soil freeze-thaw process. Satellite images have captured dust emissions from topographic depressions such as valleys, foothills, and basin in Mongolia. We observed that the amount of sand saltation at a 10 cm-height was 150 to 200 times larger at a topographic depression than that at its surrounding area for March 10 to April 22, 2015. A PM<sub>2.5</sub> concentration was 5 to 10 times higher at the topographic depression than that at its surrounding area in a dust event at April 22, 2015. This observation suggests that this topographic depression is the major dust source in TsO. In this presentation, we will discuss role of aeolian erodibility factors on variations of threshold speed.

**Keywords:** Gobi desert, Aeolian erodibility factor, Saltation of sand

### **2. Effect of ground surface erosion and deposition distribution on spatial heterogeneity of soil grain size on nebkhas and interdune in the desert-oasis ecotone of northwest China**

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Plants play a very important role in forming *nebkhas* in arid and semi-arid area. In this paper the regular pattern of ground surface erosion and deposition and their effect on

the spatial variation of soil grain size on *Tamarix ramosissima* nebkhas and interdune were investigated in Qira oasis-desert ecotone at the southern rim of the Taklimakan Desert. Our investigation showed that there are different characteristics of surface erosion and deposition in grounds with different vegetation coverage. The surface of nebkhas and interdune is mainly in the process of sand accumulation in the plot where vegetation coverage is about 30%. The nebkhas body and leeward shadow are mainly in the process of sand accumulation, while the interdune is mainly in the process of wind erosion when the vegetation coverage is 10~20%. The surface of both nebkhas and the interdune is mainly in the process of strong wind erosion when vegetation coverage is <5%. The distribution of soil grain size is closely related to distribution of surface erosion and deposition. With the decrease of vegetation cover from 30% to <5%, the average particle size in the 0-10 cm soil layer increased from 74.41 $\mu\text{m}$  to 92.71 $\mu\text{m}$ , clay disappeared and coarse sand appeared. Under the same vegetation cover, the minimum soil particle size was mainly under the shrubs while the maximum particle size was mainly distributed in the interdune. The quality of the interdune soil was the best while under shrub was the worst, which corresponded to the degree of soil erosion in interdune and the deposition on nebkhas surface. With the decrease of total vegetation cover, the differences of average values of particle diameter between different parts of nabkhas surface are significantly reduced. Viewed from the angle of nebkhas stability, the total vegetation coverage should be maintained at least > 10% in desert-oasis ecotone.

**Keywords:** Nebkha, Surface erosion, Sand deposition, *Tamarix ramosissima*, Vegetation cover

### **3. An unsustainable road towards sustainability: a review of anti-desertification strategies in Northern China**

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This paper addresses the question of sustainability in the Chinese government's conservation intervention in combating aeolian desertification in northern China. Aeolian desertification (AD), land degradation related to wind activity, has been a severe environmental problem in arid, semi-arid and sub-humid areas of northern China, affecting more than 1.6 million km<sup>2</sup> and 200 million people in the area. In the last 20 years, the central government has formulated and implemented policies to combat AD with significant achievements. However, there is an insufficient understanding of nature-generated desert land and anthropogenic aeolian desertified land (ADL). The confusion

of these two distinctively different processes led to an “anti-desertification” policy that tends to treat all desert land as desertified land, and the attempts to convert deserts into non-desert land by massive afforestation. In the name of turning the yellow desert green, economically profitable trees and bushes were planted in large areas of natural desert that does not need any conservation intervention, turning the anti-desertification policies into an unsustainable practice. This paper examines this “anti-desertification” strategy of “Greening the Desert,” and two other associated policies of developing the “Sand Industry” and “Expanding the Oases.” We argue that while the dual aims of restoring degraded land and utilizing economic resources, hence “killing two birds with one stone”, is an admirable policy goal, such duality in the framing of “restoration of aeolian desertified land” often brings about adverse consequences such as the destruction of the protective surface crust of Gobi desert and the depletion of underground water reserve.

**Keywords:** Ecological restoration, Improvable desert, North and northwest China, Sustainable land management, Water depletion

#### **4. Improving erosion risk management in transboundary river basins for better regional environment: A case study of the Upper Blue Nile River**

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In the drought-prone Upper Blue Nile River (UBNR) basin of Ethiopia (area = 172 000 km<sup>2</sup>), soil erosion by water is widely believed to be the major land degrading agent resulting in both a significant on-site and offsite consequences affecting the countries downstream. However there have been limited systematic studies addressing such a typically diverse agro-ecologic basin, mainly because of insufficient data and lack of adoptable methodologies. We analyzed variability of soil erosion, prioritized erosion-risk areas and proposed management options to minimize the impacts through integrated application of field observation, spatial analysis and modeling. Results show that the basin generates an average soil loss rate of 27.49 (range = 0-200) t ha<sup>-1</sup> yr<sup>-1</sup>, with overall soil loss value of about  $4.73 \times 10^8$  t yr<sup>-1</sup>, of this about 5% comes from gullies and 26.7% leaves the country. Variation in agroecology (average factor score = 1.32) followed by slope (1.28) were the two major factors responsible for this high spatial variability. Soils and land use types each had a relative importance by a factor of about 0.85. About 39% of the basin is experiencing from severe to very severe (> 30 t ha<sup>-1</sup> yr<sup>-1</sup>) soil erosion

problem and this is strongly linked to the population density. If appropriate soil and water conservation practices targeting about 79% of the moderate to very severe erosion-prone areas ( $> 15 \text{ t ha}^{-1} \text{ yr}^{-1}$ ) are implemented, the total sediment yield from the basin could be reduced by about 62%, that can minimize downstream reservoir siltation, flooding and pollution problems. Strengthening the regional environmental data monitoring programs to improve access to good quality and representative data for detailed planning and research purposes still remains important.

**Keywords:** Soil erosion, Water conservation practices, Environmental data monitoring

## **5. Adoption of advanced techniques to improve national resilience to climate change in Lebanon**

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Lebanon is witnessing extreme climatic variability associated with severe hydrological and agricultural drought. Observation over the last forty years shows an increase in average monthly and average annual temperature by 1.5-2.0 C coupled with a decrease in rainfall by 6% and regression of forest cover. Comparing the Normalized Differential Vegetation Index between 1999 and 2012 showed negative change in 11700 ha of the territory and the occurrence of hot spots in 6000 ha of the Lebanese land. Rainfall pattern and fast snow melting are reported as the two main factors of recurring floods and forest fires. The creation of the early warning platform (SuNaR) at CNRS-Center for Remote Sensing created the potential to build national resilience to adapt to climate change and enhance national preparedness to drought. The platform uses advanced remote sensing tools for the monitoring of water quality, observation and monitoring of land surface temperature, standard precipitation index, vegetation health index, burn severity index and algorithms to map the areas prone to flood and forest fires and provide early warning for prevention and risk management. A temperature-index snowmelt model between 2002 and 2013 using *Tropical Rainfall Measuring Mission* was developed to simulate hydrological processes of surface runoff, groundwater recharge, evapotranspiration, and snow accumulation and melt. Research undertaken at the CNRS is targeting crop reaction to increased temperature and water shortage through the improved agricultural practices. Results show the possibility to improve the resilience of irrigated field crops to high temperature effect and deficit irrigation, revealed by lower canopy temperature, better biomass production and higher water productivity.

**Keywords:** Climate change, Early warning platform, Water productivity, Remote sensing

## 6. Diversity and distribution of bacterial species compositions in sand dunes in an Asian dust source area, the Gobi Desert

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Microorganisms associated with particles in East Asian desert regions are transported up to atmospheric area and dispersed to downwind environment by Asian dust (Kosa) events. There is a possibility that the transport of microorganisms beneficially and negatively impact ecosystems, human life, and atmospheric processes. However, bacterial communities in dust source regions such as the Gobi Desert have rarely been investigated. In this study, air samples and soil samples were collected from the Gobi desert areas. The microbial communities in soils and airs were analyzed and compared to each other for elucidating the transport process from ground surface to atmosphere. The methods used in this research were DNA extraction, PCR amplification, and purification, then sequencing using MiSeq sequencing approach targeting 16S rRNA genes. MiSeq sequencing approach revealed that bacterial communities in the sand samples were predominantly composed of the phyla Proteobacteria, Actinobacteria, Acidobacteria, and Bacteroides. The members of genus *Sphingomonas*, which are soil bacteria and could be pathogenic to human and plants, occupied most parts of the bacterial communities. Air samples included the families of Micrococcaceae, Bacillaceae, Sphingomonadaceae, Oxalobacteraceae, Bradyrhizobiaceae, Chitinophagaceae, and Cytophagaceae, which were similar to the bacterial compositions in sand samples. These bacterial communities are predicted to disperse to downwind environment during Kosa events. Additionally, we analyzed heavy metals in soil of Gobi desert. We assessed the relationship between bacteria and heavy metal.

**Keywords:** Microbial communities, Asian dust, Gobi desert, DNA sequencing

## 7. Practical techniques for desertification control and livelihood improvement in the Sahel, West Africa

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Desertification is one of the globally concerned problems with complex phenomena related to land degradation and poverty. Despite great efforts in these decades, the problem still remained unsolved. Under increasing population, desertification is primarily caused by daily subsistence livelihood activities, especially in semi-arid Africa. This is a difficult aspect, since local people have to combat desertification without addressing its underlying causes. Technique should, therefore, be designed to satisfy desertification control and livelihood improvement concurrently. In this presentation, we introduce some of the cases of practical techniques, which were developed together with local people, toward the afforestation site located in agro-pastoral ecotone under ‘Great Green Wall for the Sahara and the Sahel Initiative (GGWSSI)’. ‘Contour-lines of Andropogon’ technique: It combines Zai (planting pit with manure) and Kukokse (line planting), which is an indigenous technique originated in Burkina Faso. It is effective in reducing water-related soil erosion, trapping nutrients and harvesting rain water. It also contributes to household economy, as the harvest of Andropogon from three rows, each 100 meter long and with a total width of 5 meters, is sometimes equivalent to millet grains consumed in one to two months.

Modified afforestation technique: Afforestation is one of the commonly practiced activities for desertification control. In our design, tree seedling and crops, such as millet and cowpea, are planted together in *Zai*. The planting pit collects rainwater, while manure encourages plant growth. The people weed the crops, and, as a result, the growth of the tree improves. Shallow tillage with animal-driven tools: Shallow tillage of soil using an animal-driven harrow, an indigenous farming tool in India, encourages infiltration of rain water to soil and, thus, improves the growth of grasses and trees. Degraded grassland, dominant in the Sahel, may be converted into productive field with this practice.

**Keywords:** Desertification control, Livelihood, Semi-arid Africa, Agropastoral ecotone, Afforestation

## **Theme 6. Biodiversity conservation**

### **1. Weed management activities and their relation to biodiversity conservation and combating desertification**

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Desertification and biodiversity situations change from year to year and place to place in most of the drylands, depending on the natural factors and human activities. Agriculture is one of the main human activities in drylands but weed control is not always a priority for some landowners. Weeds use many of the limited dryland resources needed for crop plants growth, depriving the crops of those resources. Weed management can limit this deleterious effect of weeds. The weed management methods have some negative and some positive effects on both desertification and biodiversity depending on their type, and time of application. Overgrazing, deep tillage (over cultivation) and herbicides are not suitable methods of weed control in dry land farming. A combination of mechanical and culture methods can successfully reduce weed pressure. Soil moisture being the most limiting factor, weed control method that conserves soil moisture will help dryland agriculture. Application of mulches and conservative tillage can reduce soil evaporation losses while also suppressing weed growth and preventing soil erosion. Generally, crop varieties and many types of weeds support drylands biodiversity. However, invasive weed species are one of the main threats to biodiversity, especially under climate changes. All the forces controlling desertification and biodiversity loss such as agroclimatic hazards and natural resource management as well as organized human activities should be understood to design proper management. Desertification can be remedied through sustainable agricultural practices and the suitable integrated control activities starting from preventive methods during seed bed preparation and minimum tillage or conservative tillage with protection of marginal lands as well as organic mulch and hand weeding during the growing seasons.

**Keywords:** Drylands, Weeds control, Drought, Soil erosion, Biodiversity, Desertification

### **2. Spatial-temporal variation characteristics of NPP in the Heihe River Basin, Notherwestern China in a recent 10 year period calculated by CASA Model**

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In this paper, the spatial-temporal variation characteristics of NPP and related factors in the Heihe River basin were analyzed using the meteorological data of the Heihe River basin, SPOT/NDVI data, and other modified mathematical statistical methods. The results show that during the 1999-2010 period the total NPP in the Heihe River basin exhibited a fluctuating increasing trend, reaching  $0.3 \times 10^{12}$  gC/a. The multiyear variation value of NPP was 0.19~601.09 gC/m<sup>2</sup> in the whole basin, 3.5gC/m<sup>2</sup> in the upper reaches, 2.06 gC/m<sup>2</sup> in the middle reaches, and 0.31 g/m<sup>2</sup> in the lower reaches. The NPP of vegetation during January and February tended to slightly decrease, and on average varied between -0.01 and -0.02 gC/m<sup>2</sup>, while in June, July, August, and September it greatly increased. The NPP of 10 vegetation types exhibited an increasing trend in 2010 compared to 1999; on average, it increased by 21.02gC/m<sup>2</sup>. Among various vegetation types, the increase in the NPP value of swamp vegetation was the largest, reaching 46.24gC/m<sup>2</sup> followed by planted vegetation, steppe types, and meadow types; their values were 39.22gC/m<sup>2</sup>, 32.49gC/m<sup>2</sup> and 27.63gC/m<sup>2</sup>, respectively. The accumulated NPP in grassland ecosystem was the largest, which is of important significance to the eco-environment of the basin. As viewed for the whole Heihe River basin, the yearly mean cumulative value of NPP of vegetation was negatively related to annual mean temperature and annual total solar radiation but positively related to annual total precipitation, suggesting that water is a limiting factor to the NPP in the Heihe River basin.

**Keywords:** NPP, NDVI, Climate changes, Eco-environment, Heihe River basin

### **3. Dragon's head (*Lallemantia iberica* F. & C. M.): A crop with new opportunity for drylands of Iran**

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*Lallemantia* (*Lallemantia iberica* Fischer & C.A. Meyer), also named as Dragon's head, originated in the Caucasian region and is cultivated from the prehistoric times in Asia (Syria, Israel, Iran, and Iraq). The crop also appears now in central and southern Europe. It is an annual plant cultivated for its seeds that contain about 30% drying oil, which is used in foods, but especially in dye and varnish industry. The seeds have traditional medicinal uses as well: as stimulant, diuretic and expectorant. It is also considered as a linseed substitute in a number of applications. The fatty acid composition

of its oil is: 6.5% palmitic acid, 1.8% stearic acid, 10.3% oleic acid, 10.8% linoleic acid, and 68.0% linolenic acid. The 12 lallemantia landrace varieties, collected from different parts of Iran by Dryland Agricultural Research Institute (DARI) in 2009, were planted in seven ecologically different locations, viz. Sararood (Kermanshah), Maragheh, Ghamlo (Kurdesta), Gachsaran, Shirvan (North Khorasan), Sarab Changahi (Lorestan), and Ilam during 2010 to 2015. The experiment carried out at Maragheh (cold region) in 2009 showed that fall, *Entezari* and spring planting of this crop was possible in rainfed conditions but fall planting at the seed rate of 400 seeds/m<sup>2</sup> was the best. It was concluded that lallemantia can tolerate low temperature up to -20 °C. In the semi-cold highland areas of Iran like Kermanshah with long-term rainfall average of 417 mm the highest seed yield was about 606 kg/ha for fall planting. In warm areas, where the winter is without frost, like Gachsaran, due to long growing season the highest seed yield was about 830 kg/ha. In other cold highland areas with frost and long winter like Shirvan and Ghamlo, the average seed yield in fall planting were about 922 and 669 kg/ha, respectively. In semi-warm areas like Ilam and Lorestan the average of seed yield were 608 and 1343 kg/ha, respectively. It showed that the highest seed yield could be obtained in fall planting of Lorestan semi-warm area. Dates of fall planting in cold and semi-cold highland areas are second week and last week of October, respectively. Date of winter planting in warm areas is last week of November. It is a crop with short growing season that needs 217 to 234 days from germination to maturity in fall planting and rainfed condition. The results of experiments in all locations indicated that lallemantia can grow well in dry areas, which makes it a potential alternative to the traditional crops in the arid zones of Iran.

**Keywords:** Lallemantia, Dye and varnish industry oil, Traditional medicine Adaptation to dry areas

#### **4. The effect of grazing exclosure on plant community diversity and structure in arid Mediterranean steppe of Algeria**

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Desertification is a worldwide concern; in Algeria, land degradation threatens more than 20 millions ha of steppe rangelands. Protection from grazing is a technique widely used for the development of the steppes. The aim of this study is to investigate the effect of grazing on plant community diversity and structure. We compared alpha and beta diversities using the Hill Index between grazed and ungrazed areas, and used the additive partitioning of beta diversity to test whether the difference in plant species composition is due to species spatial turnover or nestedness. In addition, we assessed soil surface

conditions; vegetation, litter, bare ground, biological soil crusts and *Stipa tenacissima* cover. For alpha diversity, grazing reduced significantly the diversity of the annual species; however, perennials were not affected significantly. The results revealed a significant compositional difference between grazed and ungrazed areas. Essentially, the additive partitioning of beta diversity indicated that ~74% of the overall beta diversity was due to species turnover and ~26% was due to nestedness. Grazing activity reduced values of the vegetation cover, and the cover of the most dominant species (*Stipa tenacissima*), was not affected by grazing. Nevertheless, the protection from grazing increased significantly the species diversity, and vegetation cover. This study highlights the importance of protection and conservation for maintaining the plant community structure and diversity in threatened ecosystems.

**Keywords:** Arid Mediterranean steppe, Degradation, Grazing, Diversity and structure, Species turnover, Conservation

## **Theme 7. Sustainable management of productivity of rangeland and livestock in dry areas**

### **1. Tolerance of desert sheep and goats to environmental stress, in association with their production and reproduction performance**

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The negative relationship between the tolerance to environmental stress and the production performance of animals is a serious problem for the livestock breeders in hot dry arid areas. Desert Barki sheep and goats raised in the Coastal Zone of Western Desert, Egypt (457 sheep and 276 goats) were grazed for a distance of 7 km under direct solar radiation on poor pasture in July and August. Individual response to environmental stress (thermal, respiratory and metabolic traits) was measured before and after exposure and animal heat tolerance index was developed. The studied production traits were body weight at weaning, yearling and at exposure, and at fecundity. Light desert lambs at weaning seem to be more sensitive to environmental stress under arid conditions, while heavy lambs at yearling seem to have difficulty thereafter in facing environmental stress of walking long distance under heat stress on poor pasture. Desert goats did not show detectable relationship between their body weight and physiological response to environmental stress. For breeding purpose, it seems that there is no antagonism between selection for tolerance to environmental stress in desert Barki sheep and goats, and selection for their production and reproduction performances under hot dry conditions. However, it is recommended to avoid exposing heavy desert sheep at yearling and light lambs at weaning to environmental stress. The small sized desert Barki goats coped better with the environmental stress under hot dry conditions than desert sheep, without detectable effect on their production and reproduction performance.

**Keywords:** Barki sheep & goats, Environmental stress tolerance, Heat tolerance index

### **2. Studies on intercropping systems of some annual salt tolerant forage crops among saltbush shrubs (*Atriplex nummularia* L.) under Sinai saline conditions**

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South Sinai agro-ecosystems are characterized by hyper arid climate and salt affected soils where saline underground water is the main source of irrigation. The study was

conducted to investigate growth traits of winter fodder crops (barley & fodder beet) and summer crops (guar & millet plants) cultivated among saltbush shrubs (*Atriplex nummularia* L.) as affected by intercropping patterns. Biological role of saltbush in soil reclamation was also studied. Two experiments were conducted under saline conditions of South Sinai Research Station, South Sinai Governorate. Twelve treatments, i.e. the combination between two plant spacing systems among saltbush with six intercropping patterns of saltbush, barley and fodder beet as pure stands in winter season. In summer season, guar and millet plants replaced barley and fodder beet for intercropping with the saltbush. The treatments were arranged in a split plot design with four replications. Plants were irrigated using drip irrigation saline water. Mechanical and chemical properties of the soil and chemical analysis of underground irrigation water were determined. Fresh and dry weights, plant height and total yields for winter and summer crops as affected by intercropping in saltbush were recorded. The results indicated that intercropping fodder beet with saltbush significantly increased fresh and dry yields as compared with fodder beet as a pure stand. In summer season, intercropping pearl millet with saltbush showed the highest significant values for fresh and dry yields. Narrow spacing (2.0 m) between *Atriplex* shrubs surpassed the wide spacing (4.0 m) in increasing total winter and summer forage production. It is concluded that inter-planting summer fodder crops (guar and pearl millet) or winter crops (barley and fodder beet) among saltbush, using saline water resources, may provide great forage biomass and nutritious feed materials for small ruminants under saline conditions of Sinai, Egypt to provide high quality feeds all year round, particularly during dry seasons.

**Keywords:** Winter and summer fodder crops, Salt bush (*Atriplex nummularia* L.), Intercropping

### **3. Effect of alfalfa hay feeding on energy utilization of Simmental beef cattle kept in Gansu province, China**

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Gansu province is a major beef cattle production area of China. Drastic and rapid transformation of cattle feeding system is being achieved in the region. The establishment of the feeding regimen allowing moving from conventional grazing to tie-feeding under confined condition is needed. The objective of this work is to determine the effect of the replacement of concentrate (C) with alfalfa hay (AH) on body weight (BW) gain and

energy utilization of growing Simmental cattle in Gansu province. Feeding and respiratory trials were conducted using growing Simmental bulls aiming at 1 kg daily gain (DG) in summer and autumn. The animals were allocated to three treatments: 1) control fed experimental diet comprising of corn stover (CS) and C; 2) replacing 10% of C with AH and 3) replacing 20% of C with AH in one-way layout design. Daily feed intake (DMI) and BW were measured during 21 days of feeding trial. The amounts of O<sub>2</sub> consumption, and CO<sub>2</sub> and CH<sub>4</sub> emissions were measured for 2 days of respiration trial following 3 days of adaptation to open-circuit respiration chambers. Heat production (HP) and energy metabolic rate of the animals were estimated in both seasons. Results showed that the DG value was greater for treatment 2 or 3 groups than that of control group in autumn, and was no significant difference between treatment 2 and control group in summer. Energy metabolic rate appeared to decrease along with the increase of DMI in autumn, and treatment 3 in summer led to DG decline without significant difference in DMI among the treatments. HP values of all the autumn treatments were greater than those in summer. It is concluded that the dietary substitution rate of AH may not affect DMI, however greater amount of AH allowance may not improve feed efficiency of growing beef cattle in Gansu province.

**Keywords:** Simmental cattle, Energy metabolism, Conventional grazing, Tie feeding

#### **4. Potential of spineless cactus and lathyrus for fodder in semi-arid central India**

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The semiarid region of central India is complex, diverse, rainfed, vulnerable, socio-economically heterogeneous, agrarian and backward relative to other regions. In addition, extreme weather conditions, like droughts, short-term rain and flooding in fields add to the uncertainties and seasonal migrations. Crop production and livestock rearing contribute 90% to the farm income, crop residue provides 67% of the animal fodder and failure of rains causes distress. Inclusion of drought resilient species like *Opuntia* (cactus) and *Lathyrus* (grass pea) into the cropping/farming systems of this region may reduce the vulnerability and add to the fodder security to livestock. Keeping this in view ICARDA-IGFRI collaborative project was initiated to utilize the *Opuntia* and *Lathyrus* species as an alternate source of feed and fodder in different land use management systems and enabling the stakeholders to increase the agricultural production and profitability in the dry areas. In total, 15 accessions of *Opuntia* were received from ICARDA and are being evaluated at IGFRI Central Research Farm for their establishment, survival, growth, biomass yield and quality. Among the different accessions, ‘Yellow San Cono’ and

‘White Rocca Palumba’ performed better with 100% survival and average pad length and width of 32 cm and 15 cm, respectively. The selected accessions are being grown under different land use systems (degraded lands, silvipasture, rainfed food-fodder system as alleys) at on station and on farm to supplement the fodder requirement of dry areas. In case of grass pea, the use of varieties ‘Ratan’ and ‘Nirmal’ with low ODAP (0.07% and 0.20 %, respectively) with complete package (seed treatment, use of *Rhizobium* culture, seed priming as agronomic practices and the utilization of grasspea in animal ration) is being scaled up (45 ha area with 240 farmers) in Bundelkhand region of Central India. The results of feeding trials in sheep indicated that grass pea grains in the concentrate mixture had no adverse effect on roughage intake, nitrogen balance, rumen fermentation and growth performance of lambs. Grass pea grain can completely substitute groundnut cake as protein source in concentrate mixture of growing Jalauni lambs with reduced cost (15%). The past three years R&D experience of cactus and grass pea in central part of semi-arid India indicates that these species have adequate potential in reducing fodder and feed crisis in dry and drought prone areas and sustaining livestock production of small and marginal farmers.

**Keywords:** Drought tolerant forages, Grass pea, *Opuntia* sp., Sheep feeding

## **5. Impact of the good rainy-year of 2015/2016 over the productivity of crops and livestock in CZWD and the livelihood of Bedouin Community**

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The Coastal Zone of Western Desert, Egypt (CZWD) is historically a pastoral area. Raising small ruminants is the main socioeconomic activity there. The area has faced major changes over the last 50 years: demographic growth, urbanization, touristic development and agro-ecological diversification. More recently, the area has faced a long drought period from 1995 to 2011, with low and erratic rainfall (< 150 mm). Paucity of rainfall has affected farming systems and household livelihood. The Bedouin communities have diversified their farming systems based on livestock, barley and fruit trees to face such long drought. In the year 2015/2016, the area witnessed a good rainfall of >400 mm, which reflected positively in the area. This study analyzes the impacts of this rainy-year on the crop-livestock farming, and the livelihood of the Bedouin community. The analysis is based on household surveys of 60 families, between March and May 2016, in the rainfed zone of Matrouh, and comparing them with the data collected on the same livestock breeders in 2014/15. The productivity of barley grains averaged 350kg/Fed in 2016 vs. no grains in 2014/15. Olive trees produced 1300 kg/Fed

this year, double that of the last year. Fig production was 3000 kg/Fed, 170% more than 2014/2015. Grazing period was less than one month in 2014/15, compared to 5 months in 2016 with good quality pasture, and significantly less use of the expensive concentrate feeds. Reproductive performance of sheep (lamb born/ewe/year) was 0.86 in 2016 vs. 0.81 in 2014/15. Estimates for goats were 1.18 and 1.3 kid, respectively.

The breeders stated that they could well recover their losses over the past drought years, however, they did not increase the size of their flocks, waiting to know the climatic conditions of the next year.

**Keywords:** Beduin community, Central Zone of Western Desert, Goats, Sheep, Drought

## **6. Market chain of the imported camels from Horn of Africa to Egypt, as a cheap source of meat**

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The aim of the study was to understand the market chain of the imported camels from Horn of Africa to Egypt. Different partners of the market chain (23 agents, 36 traders, 22fatteners and 16 butchers) were interviewed during 2011/12. The study covered four main camel markets: 1) Shalateen, south of Egypt at Sudan borders, 2) Daraw, Aswan government, 3) Berqash, Giza government, and 4) Belbais, Sharqia governorate. These markets receive camel herds from Horn of Africa countries (Sudan, Somalia, Djibouti, Eretria and Ethiopia ). There are two pathways to transfer these camels, the first and main one is camels trekked on hoof from Sudan in a long journey to Shalateen and Daraw (for 40 days). In the second one, camels are shipped from Somalia, Djibouti, Eretria and Ethiopia through Red Sea to Suez port; then they are transported by trucks to Berqash and Belbais markets. The survey revealed that the number of camel agents (representative of the camel owner in country of origin) in Shalateen, Daraw and Berqash markets are 14, 10 and 14, respectively. Agents classify the received consignment according to the animals' number and weight (>200 and > 500 kg). Most of traders are working in more than one market and cooperate with each other. The average weekly transactions were 35, 69, 24 and 17 camels / trader in the Shalateen, Daraw, Berqash and Belbais markets, respectively. Camel fatteners practice different types of agriculture activities, besides camel raising (66%, 50%, 100, and 33%, respectively). Average transaction was 13, 11, 3 and 8 camel/ fattener, respectively. The common constrains facing camel fatteners were increasing feedstuff prices and absence of veterinary care. Average number of camel slaughtered weekly was 3, 4, 7 and 7 per butcher, in the four markets respectively. Importing live camels to Egypt is historically an important regional

trade, but still very traditionally organized. Data from slaughter houses showed that meat from imported camels was 28417.8 ton in 2011/12 and is growing. It contributes around 12 % of the total meat produced in Egypt. Camel is considered a cheap source of meat in many parts of Egypt, especially in Giza and Sharqia governorates. It is important to pay more attention to improving its market chain to promote inter-regional trade with Horn of Africa.

**Keywords:** Market chain, Camel, Egypt, Horn of Africa, Meat production

## **7. Case study for dryland management and rehabilitation in Jordanian Badia**

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The Governing Council (GC) of the UN noted that the available information and analysis confirmed that there was a large influx of refugees and their livestock into Jordan as a result of Iraq's invasion of Kuwait. Also a large increase in the numbers of refugees and livestock caused significant environmental damage to Jordan's rangeland and wildlife habitats in the dryland area. The final estimate of the effect was recognized as damage to 7.1 million hectares of rangeland in the Jordanian Badia and loss of wildlife and destruction of rangelands wildlife habitat led to loss of non-endangered wildlife populations. In April 2013 a Community Action Plan (CAP) was developed. It is a cooperative action plan seeking to apply the appropriate biophysical and technical measures for restoring the degraded dryland in the Jordan Badia involving the local community in the implementation and in establishing and running a sustainable grazing management system. Since it would be impossible to include the whole of Badia, which accounts for 80% of the country, twelve watersheds were selected that have the highest potential for restoration, and represent about 12% of Jordanian national area. The CAP consists of three main components: a. Biophysical component, entitled "Integrated watershed management" that aims at enhancing the water security of the Badia rangelands and provides an opportunity for the fodder crops to grow, and drylands to recover the biodiversity; b. Socio-economic component entitled "Integrated livestock and socio-economic management" that provides care for the livestock, packages of incentives that motivate and support the herdsmen to cooperate in the rangeland restoration efforts and builds capacity among their community for sustainable development of dry land resources; c. Integrated component that utilizes the principles of the above components to establish a system of sustainable fodder crop production, which is managed and utilized by the community through cooperatives.

**Keywords:** Badia, Environmental damage, Integrated watershed management

## 8. The concept of integration of aquaculture and agriculture in Egypt

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The food security is one of the important issues for the policy makers in Egypt. Land and water scarcity are among the leading constraints to the Egyptian agricultural production. Expanding aquaculture projects in Egypt overloaded the required fresh water needed for agriculture. Therefore, new aquaculture areas should be utilized. Today, more than 130 intensive tilapia rural farms and 25 commercial aquaculture farms have been constructed in various desert zones of seven different provinces. In 2014 the Egyptian integrated desert aquaculture has produced 2,444 tonnes fish using around 270,000 m<sup>3</sup> of fish water tanks, with an average production 10 kg of fish/m<sup>3</sup>. Pioneer desert aquaculture farms have reached a fish biomass production ranging from 25 to 50 kg/m<sup>3</sup>. The main fish produced with 90 % of the total desert aquaculture production was Nile tilapia (*Oreochromis niloticus*) and red tilapia (*Oreochromis mossambicus* x *Oreochromis niloticus*) and the remaining 10% was mainly the North African catfish (*Clarias gariepinus*), flathead grey mullet (*Mugil cephalus*), European seabass (*Dicentrarchus labrax*), Gilthead seabream (*Sparus aurata*), and Eel (*Anguilla Anguilla*). The water source comes from Nile, geothermal underground water, agricultural drainage and/or brine water from the desalination stations. The water temperature is ranging from 22 to 26° C and salinity from <0.5 to >26 g/l. Most of the commercial aquaculture farms have adopted flow-through systems (FTS) to mainly irrigate agricultural land in desert zone, with the advantages of producing three different crops (fish/plant/sheep), in addition the biogas. While most of the farms are strictly dependent on FTS, three of them have upgraded their systems to include recycling system in both fresh and brackish water. Although the brackish water used for aquaculture purposes varies in salt concentrations, (> 26 g/L), it is utilized for integrated agriculture, e.g. the irrigation of different halophytes plants, mainly Salicornia (*Salicornia europea*), Suaeda (*Suaeda aegyptiaca*) and Atriplex (*Atriplex hortensis*) combined with intensive European seabass and gilthead seabream aquaculture, with a yearly production of 50 tonnes per year for both species. This review presents the desert aquaculture current situation, best practices, lessons learned and experiences as well as future sustainable development projects, mainly the planned agricultural mega-projects, for the reclamation of 630,000 ha of desert land for this purpose.

**Keywords:** Aquifer, Brackish aquaculture, Geothermal underground water, Egypt, Integrated aqua-agriculture, Tilapia, Water scarcity.

## **Theme 8. Arid lands communities, their indigenous knowledge and heritage, and socio-economic studies**

### **1. Rural development in dryland areas of the Qinghai-Tibet Plateau of China: problems and prospects**

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The Qinghai-Tibet Plateau is a large area in western China that has some of the world's driest deserts and highest mountains. It is the water tower of Asia with the headwaters of major rivers, including four transboundary ones. The people and their livestock are well adapted to the extremely harsh conditions. Survival depends on application of local ecological knowledge (LEK) built up over generations. Rural development faces many challenges because of: i) Sparse populations without permanent habitations, ii) Strong cultural traditions and religious philosophy, iii) Lack of infrastructure (roads, bridges, railways, mobile phone towers), iv) Low level of formal education among local peoples, v) Widespread poverty in some areas, leading to ecological refugees, and vi) Impending climate change (melting glaciers, floods, landslides). The government response is to:

- improve the public infrastructure e.g. the newly completed high speed railway to Lhasa that connects Beijing and other east coast cities to Tibet via Qinghai, upgraded highways, airports
- Encourage sedentarization of semi-nomads by creation of villages with schools, medical clinics, welfare office for pension payments to eligible citizens etc.
- Assist in relocating ecological refugees, step up the campaign to alleviate poverty
- Implement measures to restore degraded pasturelands, combat desertification and protect biodiversity
- Implement strategies to mitigate the impact of climate change, including risk analysis, campaigns to raise awareness among the herders and farmers, provide assistance to those most under threat.
- Promote socio-economic and ethno-anthropological studies to better inform government intervention strategies, including ways to better use LEK in government initiatives.

This paper will focus on experience gained from working with Tibetan ethnic groups in the "Three Rivers" region in the headwaters of the Yellow, Yangtze and Mekong rivers. Data are presented from field work based PRA and other sociological tools that sought to assess the attitudes and expectations of local people to impending global change, including global warming.

**Keywords:** Local ecological knowledge (LEK), Rural development, Tibetan ethnic groups

## **2. Added value from industries introduced in villages, reclaimed lands and oases**

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A considerable portion of the agricultural resources is being treated as valueless waste. This leads to the loss of sustainable resources as a comparative advantage and the associated loss of opportunity of sustainable development. This can be attributed to the narrowness of the angle by which we are accustomed to view these renewable resources, as well as the absence of the appropriate means to turn the waste to wealth. The first aspect is associated with the level of the R & D activities. The role of the researchers is proceeding from the understanding and valorization of the traditional technical heritage of use of these resources, to develop a contemporary method for the use of these resources, to rediscover them as a material base for the satisfaction of human needs on the local, national and international levels. The second aspect is associated with industry. Industry here is understood in broad terms as those activities conducted under defined conditions to transform the state, shape or properties of the agricultural resources to satisfy a certain requirement along a predetermined path of transformation to a final product. Based on this definition, industry includes a wide spectrum of activities including: sorting (to various sizes or quality levels), packaging, drying, freezing, pressing, squeezing, filtering, threshing, baling, etc. The above mentioned definition opens several degrees of freedom: in selection of geographical location of industry (e.g. in village, town or city), in site selection on the microscale (e.g. field, field head, house, workshop, industrial premises) of various areas and infrastructural requirements, manpower involved (e.g. men, women, children), source of power (human labor, sun, wind or water energy, or energy from hydrocarbons), level of technology (manual, mechanized, fully automated processes), and mobility (e.g. stationary or mobile as for example fish processing on board of fishing ships). Industry could also be classified into preparatory processing of a resource and the processes of manufacture of a final product. In this paper the new vision of whole resource use will be illustrated giving different examples. A new perception of resource components will be given to associate them structurally with the performance criteria of different products / services. An integrated approach will be suggested for the industrialization of the rural areas to realize the objective of endogenous sustainable development, as well as a high added value along the value chain, from the field to the market, including selection of industrial projects, their spatial distribution and appropriate technology.

**Keywords:** Industries, Rural development, Waste management

### **3. Response of rangeland communities to land use changes and climate change: the case of pastoral farmers of Narok County, Kenya.**

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Narok County's arid and semi-arid area is a pastoral livestock production system, incorporating ruminants and wild game. Nationally, livestock contributes to substantial gross national product - meat, wool and skin exports. Livestock also contributes to food production by converting roughages into meat, milk and blood and to rural employment. The game also contributes to gross national product by bringing in foreign exchange by local and international tourism. Recently and perhaps because of climate change, the production system is transforming into mixed livestock-crop system. A study was conducted in smallholder production sites of Ololulunga and Nturumeti, to determine land use changes, management and production strategies. Using random sample of 32 households, five key informant interviewees and four focused group discussions were conducted in November, 2014. Results indicate that livestock and arable farming are competing favourably for inelastic land resources owned and utilized by households, 81% and 19%, male and female headed, respectively. On average, 65% of households apportioned 50% of their farms, mean size 7.5 hectares, for farming of cereals (wheat and or maize) and the remainder to livestock. The pastoral herd, where cattle predominated, is also changing with sheep becoming dominant. Furthermore, 'Red Maasai' sheep (RM), hardy breed suitable for extensive rearing, is rapidly being replaced with 'Dorper', a higher producer of milk and carcass. With land ownership transforming from group ranches to individual, nomadic pastoralism is shifting to sedentary production even though transhumance becomes handy during the dry season. To support large livestock numbers, deliberate pasture production and conservation practices, crop residue bulking, and reseeded are inbuilt in livestock rearing. The changing land use and management strategy is posing serious land degradation threats, overgrazing, soil erosion and deforestation. Indeed, infusion of land management innovations, technology and conservation strategies are integral in ensuring continued productivity of land resources.

**Keywords:** Land-use, Pastoral system, Smallholder, Narok county, Small ruminant

### **4. Supplementary sources of income for farmers ameliorating salt-infested soils in Port Said Governorate**

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The soils of Port Said Governorate are typical coastal soils providing many opportunities and constraints for sustainable development. The agricultural land area is

about 135,000 faddans (1faddan = 4200 m<sup>2</sup>), extending towards both east and west of Suez Canal. The objective of the current work was three-fold: i) to augment the soils database; ii) to characterize soil suitability for production of various crop; and iii) to identify cheap, simple, and adaptable modern technology to support local farmers. Forty soil profiles across the governorate were morphologically, physically, and chemically analyzed. The data reveal considerable spatial variation due to variation in mode of soil formation and impacts of ambient environment. Invariably, the soils are affected by excessive salinity. Sodicity is also common coupled with high exchangeable Mg content. Spatial distribution of soil properties was elaborated using ArcGIS 9.2 software and geostatistical analysis tools. Almagra MicroLEIS model was used to produce soil suitability maps for selected crops. The model indicates that the projected agricultural production potential of most soils for most crops is poor. Salinity and sodicity were the main limiting factors. The conventional wisdom prescribes the application of appropriate doses of gypsum and subsequent leaching with large volumes of water to remove sodicity and salinity. However, it is to be recognized that the process is costly, tedious, and requires years for perfect amelioration of the land. In these circumstances, especially for small land owners who are usually short of cash to maintain a humane life support system, one or more of three options was considered: The first is to establish a greenhouse where rice stalks are used as an artificial soil bed to support cultivating vegetable crops. The second is to establish a greenhouse over a productive soil to produce seedlings and ornamentals on commercial scale. The third is to grow fish in rice fields. Each of these options offers not only socio-economic benefits, but environmental as well.

**Keywords:** Coastal soils, Soil suitability, Agricultural technology, Modeling

## **5. Adobe architecture, between tradition and innovation**

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The most important thing that links people together is Earth; Indian wisdom says: "Soil and Soul belong together". One can easily feel and see the members of the family along with their neighbors and friends, happily preparing and working together to build their clay homes by using the earth as a building material. Unfortunately, the industrial revolution in the construction sector with its high technology achievements could not provide sufficient help to the settlement branch in our developing countries as promised. On the contrary for the last few years, we could create sustainable, economic, healthy and human settlements by applying and improving the traditional Adobe Architecture. According to the Kyoto Agreement in 1997, countries have agreed to reduce the use of the following productions until the year 2050: Reinforcing rods down to 80%; Aluminum down to 90%; and Cement down to 85%. The question arises as to how do we keep this

agreement if we don't use the natural available building materials, i.e. clay and applying appropriate technology? This paper will review: (1) History of Clay Architecture; (2) Improvement methods of Adobe construction; (3) Examples of appropriate improved Adobe Architecture Projects in Egypt (Desert and urban area); Africa (Burkina Faso, Senegal, Somalia) and Asia (Saudi Arabia); and (4) Practical training of local crafts and students.

**Keywords:** Clay architecture, Examples of Adobe construction, Kyoto Agreement 1997, Training of local crafts

## **6. Economics, high value cultivation in the drylands**

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Agricultural production in the drylands - especially on desert lands needing amelioration - is far more costly than in the normal well-endowed agricultural lands because for it to succeed such agriculture has multiple requirements of land development, inputs and management. The growing medium here is mostly sand with very poor fertility, needing input of all types of nutrients to support plant growth. Provision of water involves high costs of transport, distribution, skillful irrigation management and energy. Knowing market needs and windows of opportunity to dispose the produce is essential to match the crop production to ensure payback for costly investments. To manage the inputs and operations for dry land desert cultivation, an eye has to be kept on the market constraints & requirements (quality, etc.), to maintain the right balance. Special post-harvest handling logistics involves costs and having a good understanding of market forces is essential to achieve cost-effective decision-making. The economies of scale have to be duly considered as also the government policies and strategies to maximize the returns on investment in dryland desert farming.

**Keywords:** Economics of desert farming, Land reclamation, Economy of scale, Market forces and demands, Post-harvest handling

## **7. Assessment of impacts, adaptation and vulnerability to climate change in North Sinai region, Egypt**

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The livelihood vulnerability index (LVI) and the Intergovernmental Panel on Climate Change (IPCC) vulnerability index (IPCC-VI) approaches were used to assess the

vulnerability of rural and urban regions of Sahl El Tina and Baloza areas, North Sinai Region, Egypt to climate change. Apparently, the region is highly vulnerable to salinity and drought that may be attributed to climate changes. The aim of the present study is to explore the socioeconomic drivers of climate change and their impacts on a farming community and to give an insight into possible mechanisms of future adaptation strategies. Equal numbers of rural and urban farmers, about 100-150 of each, were interviewed to collect information on human and natural capital, besides social, financial, and physical attributes impacted by climate changes. The study showed that drought is the most significant manifestation of climate change, especially in rural areas. Rural Sahl El Tina and Baloza communities are significantly more vulnerable to climate change than the urban community. Their isolation, illiteracy, lack of awareness, and fragile ecosystem are causes of vulnerability. The two areas in the regions showed high capabilities to overcome exposure threats to climate change. Adequate adaptive capacity of farmers is the main cause for their ability to overcome climate change impacts. These results might be explained in view of farmer local knowledge that helps them to survive even through the harshest times. The preliminary results showed that there was an overall reduction in crop yields under climate change even when adaptation was taken into account. Changes in crop variety, crop calendar, and irrigation, and the amount and nitrogen fertilization were the main options produced through the analysis steps. It is concluded that the involvement of the rural population and extension services in capacity building programs is an essential adaptation measure, with rapid information flow among and between these two groups.

**Keywords:** Livelihood vulnerability index, Climate change, Farmer's local knowledge

## **8. Rural women's empowerment in a dryland community: The case of the New Valley governorate, Egypt**

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The objectives of this study are to: i) Measure the rural women's empowerment level, and ii) Determine factors affecting it. Data were collected through personal interviews of 300 rural women (240 from Al-Mounirah village belonging to El-Kharga district and 60 from Al-Thaniyah village belonging to Darb El-Arbaien, Paris District), during the period from May to June 2016, using a questionnaire. Frequencies, percentages, range, average, standard deviation, weighted average (relative weight), T test, Pearson's simple correlation, Step-Wise Regression Analysis, and verification of hypotheses were used for data processing and presentation. Findings revealed that dimensions of rural women's empowerment could be ranked as social (relative weight =

60.8%), cognitive and psychological (RW = 60.7% for each), economic (RW = 58.7%), and finally the political dimension of empowerment (RW = 56%). Of the studied eleven independent variables, eight variables accounted for 71.9% of variance in rural women's economic empowerment, seven accounted for 61.7% of variance in political empowerment, eight accounted for 69.6% of variance in social dimension, one accounted for 4% and 1.6 of variance in cognitive and psychological dimensions, respectively. Results also indicated that the eight independent variables (family type, average of sons' education, average age of sons, family size, women's age, women's employment status, and husband's age) accounted for 63.4% of variance in rural women's overall empowerment. The study concluded that rural women's empowerment could be strengthened through support factors influencing it.

**Keywords:** Rural women, Empowerment, Drylands, New Valley (Egypt).

## **9. Maximizing the use of wild medicinal plants for the development of populations in the South East of Egypt**

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This study was conducted in the area from Shalateen to Halayeb in South East of Egypt. The study aimed at maintaining and organize use of medicinal wild plants to maximize the economic return in this area to the Bedouins, and also to increase their share in the total market value of medicinal plants that they collect and add value to. Forty six stands representing 13 localities were selected to study the distribution, habitat, density, productivity, chemical composition, and active materials of the medicinal plants in the study area. The marketing study was conducted through the survey of the local market to determine the types of products to be developed (oil extraction, herbal teas, wholesale), the types of customers and their requirements, create a brand for the products, and develop the packaging and design holder for the products. Forty-four medicinal and aromatic species were recorded in the study area. These plants are distributed in eight habitats. The highest density was recorded of *Zygophyllum simplex*, followed by *Rumex vesicarius* and *Chenopodium murale*. *Rhizophora mucronata* had the highest productivity followed by *Avicenna marina* and *Lycium shawii*. The ash content ranged between 3.34% (*Balanities aegyptiaca*) and 32.86% (*Salvadora persica*). Tannins, saponins and alkaloid contents were also evaluated. The marketing study revealed that more than 50% of the herbs exported were sold in bulk. None of the herbs most requested for export was from Shalateen. The local marketing and the customers of five medicinal species selected from these species were surveyed. The package type and form of these plants were designed and named as Shala-Tea products. These plants are: senna (*Senna italica*), lavender cotton (*Achillea fragrantissima*), desert dates (*Balanities aegyptiaca*), bitter apple (*Citrullus colocynthis*), Kaf Mariam (*Anastatica hierochuntica*), and hibiscus (*Hibiscus sabdariffa*).

**Keywords:** Bedouins, Wild medicinal plants, Value addition, Marketing

## **10. Evaluating different policies to support organic agriculture adoption in Egypt**

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A very important pillar of the modernization of the Egyptian agriculture is the exportation of the high value added products such as organic products. In spite of the importance of the organic agriculture within the Egyptian agriculture sector, to best of our knowledge, there are no studies in Egypt that try to analyze the factors that determine the adaption of organic agriculture on the Egyptian farms. The main objective of this project, therefore, is to determine and analyze the importance of different public policies applied to support the adaption of organic agriculture and the social acceptance of these policies among Egyptian farmers. This will be helpful in designing suitable policies and strategies to support the extension of organic agriculture in Egypt and assure the social acceptance of these policies. In order to achieve this objective we carried out a survey with a representative sample of organic and non-organic farms in the Upper Egypt area, namely in Suhag, Assiut and Fayum governorates, which are considered as the main production area of organic products. The methodological approach is based on the use of choice experiments (CE) and the Analytical Hierarchy Process (AHP) techniques to examine the social acceptance of four policies to support the adoption of organic agriculture in Egypt. Our preliminary results suggest that the most accepted policy to support organic agriculture adoption in Egypt is the availability of subsidy followed by the establishment of a governmental certification body. Other policies such as reducing the certification cost and the availability of long contracts seem to be less effective in promoting organic agriculture adoption in Egypt.

**Keywords:** Organic farming, Policy support, Certification of organic products, Upper Egypt

## **11. Linking farmers to market in Upper Egypt: A case study**

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It is about the challenges and the lessons learned from SALASEL project, which started in January 2010 and shut down in June 2013. SALASEL is the short name of Pro-poor horticulture value chains in Upper Egypt project funded by MDG-F and implemented by 4 UN agencies, UNDP, UNIDO, ILO and UN WOMEN with a total

budget of \$7.5 M in 6 Governorates in Upper Egypt. The Government of Egypt was represented by the Ministry of Industry & Foreign Trade (MIFT) and the General Authority for Investment (GAFI). The presentation gives a brief about SALASEL, the main challenges of the project and what were the strategies to resolve these challenges. Then the lessons learned are presented classified into 5 main topics: start up, organizational, community development, sustainability and technical issues. Most of the mentioned strategies and the lessons learned can be replicated in the new communities or new development programs.

**Keywords:** SALSEL project, Horticulture value chain, Upper Egypt, Community development

## **12. Linking small and marginalized farmers to markets; the importance and approaches**

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Over the last years, agricultural development at the level of small-scale and marginalized farmers was modest and below target. One of the major reasons behind that low performance is the absence or neglect of market improvement dimension. Traditional and underdeveloped marketing systems represent the main obstacle facing agricultural development and hamper its effectiveness.

Recently there is a growing interest in the improvement of agriculture marketing as a key element and a necessary condition for agriculture development, mainly at the level of small and marginalized farmers. The concept of “linking farmers to markets” has become a matter of growing interest, especially for the international and regional agricultural development agencies. Linking farmers to markets could play a significant role toward bridging the widening gap between the poor performance of small scale farming and the rapid dynamic changes of agro-food systems, for the welfare of small farmers. Through successful linkages, small farmers could improve quality and safety standards of their products, decrease pre- and post-harvest losses, minimize the degree of marketing risks, integrate into agro-food exporting activities, and ensure fair and rewarding farm gate prices for their products. There are different approaches to link farmers to markets. Among these approaches are the contract farming, linkages through farmers associations and leading farmers, and direct marketing. This paper illustrates these approaches.

**Keywords:** Agricultural development, Small scale farming, Market linkage

### **13. Enhancing faba bean production and productivity through the demonstration of innovative technologies on farmers fields**

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Faba bean (*Vicia faba* L.) is the most important food legume crop in Egypt, being a good source of quality protein in the diet of people, and for animal feed. Increasing faba bean production and improving its nutritional quality is thus crucial to meet the demand of the increasing Egyptian population. Five high yield-potential faba bean cultivars were tested along with integrated management techniques for key diseases, insect pests and *Orobanche* at five locations of Delta region in three seasons (2012/13 to 2014/15). Results showed that the productivity was highest in Dakahlia in all the three seasons (5.59, 5.23 and 4.56 t ha<sup>-1</sup> respectively). The test of *Orobanche* control package in the demonstrations on *Orobanche*-infested soil at Dakahlia, Sharkia and Assiut indicated that the yields of two tolerant cultivars ('Giza 843' and 'Misr 3') exceeded those of farmers' varieties by 11.1 to 35.7%. The mean increase in seed yield of demonstration fields over those of the neighboring farmers' fields were 22.5, 22.5 and 28.8%, respectively, in the three seasons. Average seed yield increase of the tolerant cultivar 'Giza 843' in the three seasons compared to neighboring fields was 0.83 and 1.48 t ha<sup>-1</sup> at Assiut and Dakahlia, respectively, whereas the increase for 'Misr 3' was 0.37 and 1.07 t ha<sup>-1</sup> at Sharkia and Assiut, respectively. The average increase of seed yield of the demonstration fields was 0.29 t ha<sup>-1</sup> at Nubaria and 1.24 t ha<sup>-1</sup> at Sharkia in 2012/13, and the respective values were 0.50 t ha<sup>-1</sup> and 1.06 t ha<sup>-1</sup> in 2013/14, and 0.49 t ha<sup>-1</sup> and 1.04 t ha<sup>-1</sup> in 2014/15. In 2013/14 the control of chocolate spot and rust diseases was also investigated through the demonstrations of resistant cultivars 'Sakha 1' and 'Sakha 4' as well as the drought tolerant cultivars 'Nubaria 2' and 'Nubaria 3'. The paper presents the results of these demonstrations.

**Keywords:** Faba bean, Field demonstrations, Productivity, Orobanche, Chocolate spot and Rust resistant cultivars

### **14. Agricultural cooperatives development, an Egyptian experience**

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In most African countries 'modern' cooperatives were introduced by colonial powers who sought to replicate their domestic cooperative structures throughout their colonies and protectorates. After independence, and until the beginning of the structural adjustment era, cooperatives received massive state support, both financial and technical;

they were given marketing and supply monopolies for agricultural commodities and inputs, which *de facto* meant that farmers were obliged to seek membership. As a result of structural adjustment program applied by Egypt and most African countries, cooperatives were subject to sudden removal of state support, the abolition of monopolies and other privileges. The situation in Egypt was very difficult for cooperatives, where the government removed all types of support while continued its interference in their operation and had not taken serious steps towards their reform. Such situation brought to light a set of triple crisis: (1) A crisis of *identity*: the existing cooperatives were cooperatives by name only, not by nature; (2) A crisis of *environment*: the legal, institutional and administrative context was preventing, not supporting, the emergence of genuine, self-managed cooperatives; and (3) A crisis of *management*: The existing cooperatives were unable to survive without subsidies, and state protection. Recently (by 2014) , the Government of Egypt realized the importance of amending the cooperative law as measure for institutional reform, to give the cooperative the chance to grow and participate in achieving the objectives of the sustainable agricultural development strategy 2030. The paper presents the situation analysis of the Egyptian agricultural cooperatives and legislative changes introduced through amendment of the existing law. The new amendments have been designed to enable cooperatives to be economically more viable and service-oriented, protect farmer's interest through creating cooperative companies, encourage collaboration with private enterprises, minimize the governmental intervention, and promote joint-use of capital and facilities.

**Keywords:** Cooperatives, Structural reforms, Legislative changes, Sustainable agriculture

## **15. Lessons learnt for settlement in reclaimed lands in arid zones: The case of Egypt**

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Egypt, a part of the most arid zones in the world, relies on the Nile River to satisfy more than 95% of its water needs that are increasing substantially due the high growth rate of its population. With increase in population the demand for food is increasing while cultivable land remains limited. Hence, land reclamation in Egypt is indispensable to expand the cultivated areas and to resettle the growing population in new communities. Yet, the fixed quota of 55.5 billion m<sup>3</sup> of Nile water allocated to Egypt from the Nile basin lets the land reclamation plans face real challenges. The conflicting need of water for economic activities, including agriculture, and household uses in reclaimed lands puts additional pressure on already scarce water resources.

Under such conditions the process of creating new and sustainable human settlements in reclaimed land in the arid zones becomes very crucial. When any agency

plans for establishment of new human settlements in newly reclaimed lands it should consider, very carefully, the various long-lasting social, economic, environmental and geopolitical goals of land reclamation as well as the future dimensions of human settlements. The planning of land reclamation should consider adoption of specific development paradigms with an emphasis on the sustainable livelihood and territorial approaches to ensure sustainable human settlements in reclaimed areas. The different societal assets and capitals, whether natural, human, social, physical or financial, needed for sustainable development, should be fully considered from the very beginning of planning of establishment of such settlements. This would save huge investments and invaluable efforts likely to be spent in such endeavor.

**Keywords:** Reclamation of lands, Resettlement of population, Water scarcity, Sustainable development

## **16. Prospective role of small scale farmers in agriculture development in Egypt**

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Small scale farmers (SSF) are still considered to be one of the most important elements in agricultural and rural development in Egypt. This study focused on the characterization of SSF and their economic and social contributions to agriculture sector and food security in the country. The data from agricultural censuses from 1929-2010 were used for this study. The holders of less than 3 feddans of land were considered as SSF generating an income to cover the UN-specified poverty line of 1.25 US\$/day/capita. The study revealed that SSF families represent 38% of the total population in Egypt, and 69% of the rural population. They provide most (about 71%) of the permanent and temporary agriculture work force and are the main producers of field crops and livestock products; but their contribution to fruit production is very limited. Despite several challenges facing the SSF that hinder their active participation in the sustainable agricultural development, such as severe land fragmentation, high rate of land transfer to non-agricultural activities, and continuous and rapid increase in input prices and land renting value, SSF have prospects and opportunities to improve their livelihood, and enhance their participation in sustainable rural and national development, because they possess traditionally accumulated knowledge in agriculture and risk mitigation, have high level of crop intensification, have integration between family and farm business and consider farming as a way of life, practice integrated crop-livestock farming system and are generating jobs for new generations.

**Keywords:** Small scale farmers, Agricultural development, Challenges and opportunities for livelihood improvement, Egypt.

## **17. Strengthen the seed industry policies in Egypt; opportunities to support the sustainable agriculture in dryland countries**

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The Egyptian seeds industry has been established more than hundred years ago, a legacy of policies liaised with global agriculture growth trends. In the last 30 years it has been subjected to major reforms to empower this industry to meet the local needs of high quality seeds. The role of private sector, however, needs to be increased in order to supply the market with new varieties that secure high-productivity, especially to those small-scale farmers that practice agriculture in the drylands. The modernization for seed industry in Egypt will promote the current efforts to support the sustainable agriculture. However, sustainable agricultural development seeks not only to preserve and maintain natural resources, but also to develop them, as future generations will have much more demand for agricultural and food products in terms of both quantity and quality. Egypt exports seeds to many countries especially those located in dryland area. However, it also imports seeds of many crops due to its climatic conditions. The paper will explore the current situation of seed industry in Egypt, with a quantitative analysis, within the scope of Egyptian Agriculture Strategy 2030, with its reflections on the future outlook in combating the food insecurity and promote the biodiversity in the face of ecosystem challenges.

**Keywords:** Seeds, Policies, Agriculture, Drylands, Sustainable development, Food security, Small-scale farmer

## **18. Supporting policies to combat desertification in Egypt.**

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Egypt is located in one of the driest regions of the world, with full reliance on Nile and ground water for different economic activities, including agriculture. Regulating policies for better utilization of these resources are of particular importance to combat desertification. Those policies can become a major tool to expand the green area in Egypt, supporting activities with high economic returns as well as limited risk in investment. These policies are: a. Develop plant varieties that are tolerant to drought or can be cultivated on low quality water; b. Provide incentives for investment for activities supporting value chains; and c. Adoption of agricultural insurance policies and risk mitigation. The paper will discuss these policies, the mechanisms to implement them and the expected positive effects of these on combating desertification in Egypt.

**Keywords:** Policies, Combating desertification, Value chain, Agricultural insurance

## **Theme 9. Renewable energy**

### **1. Opportunities and constrains of renewable energy deployment in Egypt**

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Energy is a critical factor to Egypt's immediate economic recovery plan and broader vision of private sector development. Egypt's historic energy security has faced a number of challenges during recent years. In the last few years, this situation has particularly serious. The gap between the production and consumption of petroleum products and electricity has been expanding, which, combined with lack in energy infrastructure, has resulted in serious outages of electricity, particularly during summer months. Subsidies to the energy sector are fiscally unsustainable, while low prices have decreased energy production and boosted demand growth, leading to an increase in energy deficit. Achieving Egypt's vision will require sustained economic growth of about 6-7% per annum with a corresponding acceleration in energy demand. Meeting this demand will not be possible without diversifying energy supply and thorough transformation of the energy sector. The New and Renewable Energy Authority (NREA) was established in 1986, to act as the national focal point for expanding efforts to develop and introduce renewable energy (RE) technology on a commercial scale and implementing the energy conservation programs. The main barriers for deploying RE in Egypt are: securing the required huge finance for RE projects by the public and private sector; the average cost of each kWh generated from RE projects is still higher than the same produced from conventional power plants due to Low Energy Tariff; and there are technical risks on the grid stability due to implementation of RE projects.

Recently, Egypt has set a target of 20% of its electricity generation coming from renewable sources by 2022 and the private sector investment will play a critical role to achieve this strategy. To meet this target, the Egyptian Government has already taken key steps to implement renewable energy strategy, which includes a major subsidy-reform program to remove the subsidy through 5 years up to 2019. Consequently, the price of the electricity generated from RE will be increased annually with same rate of the wholesale electricity. The other step is issuing the new Renewable Energy Law to provide clarity on Feed in Tariff procedures and enabling legal provisions and announcing an interim target for the first regulatory period through Feed In Tariff program (2015-2017) with total capacity of 4300 MW of both solar and wind energy. To achieve this ambitious target of renewable energy in Egypt, there is a necessity to promote the participation of the private sector in this program through providing governmental support, clear incentives and guarantee. In addition, steps will be taken for enhancing the cooperation with both industrial & educational partners to transfer and adapt to local conditions the wind and solar technology in Egypt. This paper will focus on the future of RE and the current

situation, main barriers of deployment of renewable energy and the actions being undertaken by the government to overcome these barriers.

**Keywords:** Renewable energy (Solar and Wind), RE Law in Egypt, Transfer and adaptation of RE technology

## **2. Production and water use efficiency of *Jatropha curcas* irrigated with agricultural drainage water: A case study of Ismailia, Egypt**

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*Jatropha* (*Jatropha curcas* L.) is a renewable source of biodiesel and it is a valuable multi-purpose crop. A field experiment was carried out at El-Mhsama, 30 km far from Ismailia, in the eastern part of Egypt. *Jatropha* was cultivated from April 2010 to June 2014 under three agricultural drainage water application levels (100%, 97% and 95% of control), two plant spacing (2.5m x 2.5m and 2.5m x 1.25m), and three NPK fertilizer levels (100%, 120% and 140% of control), to evaluate the productivity in marginal soil. The results revealed that the highest values of seed and crude oil yield were recorded with *Jatropha* shrubs that were irrigated by 95% of control for standard and narrow plant spacing. The yield of extracted oil was 130.1, 233.6 and 283.3 kg ha<sup>-1</sup> at 100%, 97% and 95% of control, respectively. On the other hand, the treatment that was irrigated by 95% of control for standard plant spacing recorded the highest value of oil in the seeds. The water use efficiency of seed, squeezed and extracted oil yield (0.29, 0.04 and 0.089 kg m<sup>-3</sup>, respectively) was also highest. The results also revealed that the highest values of seeds and oil was obtained at 100% of NPK fertilizer, while the lowest values were obtained at 140% of NPK fertilizer. It could be concluded that the highest dry matter and water use efficiency of seed and oil were recorded with irrigation with 95% drainage irrigation water of control for standard plant spacing. While, the highest seed and oil yield were recorded with 95% of control for narrow spacing with using 100% of NPK fertilizer.

**Keywords:** Renewable energy, Agricultural drainage water, Plant spacing, Fertilizer, Plant oil, Water use efficiency

## **3. Development of mobile stand-alone solar driven reverse osmosis desalination plants for sustainable development in Egypt**

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Egypt is experiencing a fresh water crisis. Many large and small communities in Egypt are suffering an acute shortage of fresh water that complies with minimum health

requirements. Water desalination projects based on reverse osmosis technology are being introduced in Egypt to combat drinking water shortage in remote areas. Reverse osmosis (RO) desalination is a pressure driven process. This work focuses on the design of an integrated brackish water and seawater RO desalination and solar Photovoltaic (PV) technology. Small mobile PV driven RO desalination plants prototype were designed and tested. Solar-driven reverse osmosis desalination can potentially break the dependence of conventional desalination on fossil fuels, reduce operational costs, and improve environmental sustainability. Moreover, the innovative features incorporated in the newly designed PV-RO plant prototype are focusing on improving the cost effectiveness of producing drinkable water in remote areas. This is achieved by maximizing energy yield through an integrated automatic single axis PV tracking system with programmed tilting angle adjustment. Mobility of the systems provides potable water to isolated villages and population as well as ability to provide good drinking water to different number of people from any source that is not drinkable.

**Keywords:** Reverse osmosis, Photovoltaic, Desalination, Northwest Coast

#### **4. Economic analysis of a stand-alone reverse osmosis desalination unit, powered by photovoltaic, for possible application in the North West Coast of Egypt**

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The availability of fresh water and energy is the key factor of the development of many countries particularly those of over-populated arid areas. Potable water supply shortage and recent technological development have led to wider application of conventional, and yet advanced saline/brackish water desalination plants. Today, desalination methods require large amounts of energy, which make them costly both in terms of environmental costs and in money terms. This study defines the main economic parameters used in estimation of desalination costs and limitation of the stand-alone, small size SWRO plants powered by photovoltaic at the North West cost of Egypt. Moreover, techno-economic study is made to estimate the actual cost of per m<sup>3</sup> fresh water production on real field measurements. All cost estimations are based on the prices prevailing during 2012-2013. The average unit cost of desalted water with the desalination unit powered by photovoltaic battery is 9.3-5.6 LE/m<sup>3</sup>, which is very high, but when using the unit without battery, the cost is reduced to be between 2.3 – 1.7 LE/m<sup>3</sup> by increase working hours to 24 hours. Economical strategies should be developed for more reduction in cost taking into account all phases from site selection and design to operation and maintenance and, most importantly, increasing the local manufacturing.

**Keywords:** Production cost, Economic analysis, Stand-Alone, Reverse osmosis, photo voltaic, Desalination, Egypt.

## **5. Innovations for long term resilience and sustainable nexus of food, energy and water system**

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The majority of wastewater treatment plants in the United States and around the world partially treat the organic solids generated as a byproduct of the wastewater treatment process by anaerobic digestion. Anaerobic digestion generates Class B biosolids which can contain millions of fecal coliforms bacteria and other enteric pathogens per gram of solids. Anaerobic digestion requires heating and keeping the organic solids above 98.6 degrees Fahrenheit for at least 15 days as per U.S. EPA rule 503 requirements. Approximately 7,100,000 dry tons of wastewater sludge are generated each year in the U.S. The wastewater sludge is usually in the form of liquid with 10% solids or less. This amounts to 64,359,712 m<sup>3</sup> per year; of which, 15% are incinerated, 28% are landfilled and 36% are applied to agricultural land. Huge problems are associated with this practice: 1) the release of a huge number of enteric pathogens into landfills and agricultural lands and potentially to ground water; 2) emitting millions of tons of greenhouse gases, such as CO, CO<sub>2</sub> and CH<sub>4</sub>, into the atmosphere due to releasing and/or flaring digester's methane gas and from extensive hauling and trucking; 3) the destruction of highways and bridges due to the repetitive highways loading and unloading by the heavy trucks and tankers hauling the mostly water sludge to landfills and agriculture lands. It requires 650 KWH per ton to dry sludge from 15% solids to 90% solids. We have adopted and improved on a treatment technology that dehumidifies the sludge to 90% solids with the use of 120 KWH per ton. We are constructing a controlled environment greenhouse adjacent to the sludge dehumidification system. The dehumidification system will produce disinfected energy and fertilizer pellets from the organic waste, high quality condensate water, electric power, waste heat, and CO<sub>2</sub>. All those products will be used in the green house to enhance production and yield of agricultural crops.

**Keywords:** Waste water, Sludge dehumidification, Greenhouse gases, Electricity generation

## **6. Current situation and prospects for solar drying and biofuels in Central Africa: laboratories, research teams and experiences**

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The work reported here gives the state of research and prospects on solar drying and biofuels in Central Africa. It happens every day without governments' involvement in the renewable energy and biofuels. Indeed, these disciplines affect several sectors. The work

of University focuses on the development of sources of renewable energy and biofuels to solve the problem of energy deficit. In this part of Africa, the solar energy is the main source for drying and is the traditional type of energy use for drying, either as direct, indirect, mixed and hybrid. To this effect, we can have biomass energy source and finally the conventional power source. The themes pursued by the research teams are focused on the development of local technologies using local materials. Each country has at least one laboratory for energy and biofuels. Central Africa has ten research laboratories in this field and majority of them respond to calls for tenders. We have identified around ten varieties of products for drying in Central Africa on which researcher are working. The energy source used here is the sun to adapt to the realities of Africa.

**Keywords:** Solar energy, Solar dryers, Laboratory team, Central Africa

## **7. Reducing post-harvest losses by solar drying: Case of Central Africa**

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The drying of food products is now almost mastered under many works to show improving the efficiency of solar dryers. As regards the indirect solar dryers used in single, mixed or hybrid combination, an analysis has shown that they are all of crossing mode and a temperature gradient exists between the trays in the dryer. An indirect solar dryer has been developed in which the airflow is manually guided in the drying chamber. The collector also offers the possibility to change the absorber and store heat through the use volcanic stones found locally. The insulation is made of wood. CESAM has praised the design as it takes into account the needs of the user. This new dryer allows three air circulation patterns in the same equipment as follows: the licking, crossing, and mixed mode. It also helps to have constant temperature reaching 68 ° C in the drying chamber. In the absence of sunlight, heat accumulated in the collector continues to create a difference of 5 °C between drying chamber temperature and that outside for up to 8 hours. The set is mainly made from local materials easily found on site and it depends solely on solar energy.

**Keywords:** Indirect solar dryer, Post-harvest losses, Heat conservation

## **8. Utilization of renewable energy sources in dryland systems**

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Use of renewable energy is becoming essential as a strategy to mitigate greenhouse-gas emission, and reduce energy use and cost of operations in Indian agriculture.

Intensive research and development activities have been, therefore, undertaken by the research institutions of the Indian Council of Agricultural Research (ICAR), State Agricultural Universities (SAUs), and other State and Central Government organizations, to develop technologies for agricultural operations using renewable energy. The Central Research Institute for Dry Areas (CRIDA) has been developing simple devices and systems for the benefit of small-holder farmers. Small solar-powered pumping systems for lifting and delivering harvested rainwater from ponds have proved promising in dryland agriculture. With 1 hp solar photovoltaic (PV) (AC & DC) based micro irrigation system, 50 micro-sprinklers could be operated covering an area of about 1 ha. Another solar- powered micro-irrigation system, which lifts up water to a certain height to run gravity-fed micro-rrigation system, can cover an area of up to 0.2 ha. Solar-powered weeder, sprayers and winnowers have been developed and made available to small-holder farmers in partnership with private sector. Solar dryers have been developed for preservation of quality of food grains, fruits, vegetables and herbs, enabling farmers to get good price in the market. Payback period of commercial solar dryers is about 3 years. CRIDA has also conducted experiments with biomass-based herbal dryer using the biogas as auxiliary source. Henna, senna, herbs, *Amla*, figs etc were drid in these dryers and the all critical quality traits were retained with good aroma when controlled drying was done at 55 degree C. Solar cabinet dryers and hybrid solar driers have been developed for increasing the value of the horticultural products before going for tertiary processing. Biogas plant of 85 m<sup>3</sup> digester capacity have been designed and promoted to be installed for dairy farms with 100 cows. The biogas so produced is sufficient to prepare feed, pump water, and operate washing system for animals and the shed-floor. In most of the processing systems in villages, it is possible to replace steam heaters with simple solar water heaters to get a temperature of 70 -75<sup>0</sup> C. A solar heater of 2500 liter capacity per day saves 20-25 liter of furnace oil in the production processes in the dairy sector. A solar lighting system has been developed and promoted for use in rural dairy plants for lighting milking area and for heating and chilling operations. Examples of these renewable energy devices are presented in this paper.

**Keywords:** Small holder farmers, Solar-powered farm devices, Biogas plant, Photo-voltaic based micro-irrigation system

## Poster presentations

### 1. Sustainable water management and eco-healthy prevention process among rural communities in semi-arid region of Tunisia

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The irrigation development in the Sidi Bouzid region embodies both the sustainability issues of the water resources management and the question of the eco-health resiliency system among the rural communities. Indeed, the intensification of the irrigated agriculture is marked by continuous pressure on water resources and strong difficulties of the collective management process. Furthermore, studies showed that the development of irrigation is a factor that increases the spread of certain diseases among the rural households. Within this context, the community of El Hechria, based around the public irrigated area of Sidi Sayeh I, showed an important risk of exposure to the Zoonotic Cutaneous Leishmaniasis (ZCL) disease. In addition, the increase of the water demand constrains irrigators to practice overnight irrigation during the intense activity of the sandfly as main vector of the disease. Hence, this research aims to identify development alternatives that reconcile a sustainable and rational use of the water resources, an effective prevention of the ZCL disease by minimizing the risk of the exposure and an improvement of the farming profitability. In order to reach this objective, field surveys were carried out among the half of the concerned farmers. By using positive mathematical programming, the farming system was modelled in order to simulate scenarios that meet the farmers' purposes. The results showed that irrigators extend their irrigable potential outside the public irrigated area through using their quota of water. This practice increases not only the pressure on water resources but also the irrigation costs. The simulation of supply chains improvement scenario suggests the opportunity to rethink the farming system leading to the consequent decrease in water demand and allowing irrigator to set up daily irrigation. Moreover, the new cropping system provides a significant increase in income that might strengthen the prevention of the disease by reducing the risk of exposure.

**Keywords:** Irrigation, Zoonotic Cutaneous Leishmaniasis, Sand fly, Rational use of water

### 2. Improving water productivity in grapevine: A case study in Urmia lake basin

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Declining water resources in Uremia Lake basin (West Azarbaijan, Iran) are pressing farmers to look for more efficient methods of irrigation than the traditional surface irrigation with low efficiency. Subsurface drip irrigation (SDI) can be a viable alternative when water is limited because water is directly applied in the root zone without losses due to evaporation or runoff. The aim of this work was to compare water use, water productivity, growth and yield of grapevine, under surface irrigation (SI), and surface and subsurface drip irrigation (SD and SDI) systems. The problem of root clogging of drippers in SDI was also studied. This study was conducted in a private vineyard located in the West Urmia lake basin. The experiment was conducted under a complete randomized block design with three replications, and data were studied by variance analysis. It was observed that SDI could reduce irrigation water use by 13% and 48% as compared with SD and SI systems, respectively. The highest and the lowest yields were obtained with SDI and SI irrigation methods, respectively, but the effects of SDI and SD on yield were not significantly different. Water productivity (WP) improved under SDI. Therefore, to increase the WP in west Azarbaijan vineyards, installing SDI irrigation system is recommended.

**Keywords:** Grapevine, Water productivity, Irrigation methods, Urmia lake.

### **3. Introduction to regional and industrial development project, International Platform of Dryland Research and Education, Tottori University**

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International Platform for Dryland Research and Education (IPDRE), Tottori University is an organization for university-wide interdisciplinary research and education in collaboration with leading scientists and stakeholders around the world, and focuses attention on a wide range of problems over the natural, agricultural, industrial and social sectors in drylands and developing countries. As problems similar to ones in drylands and developing countries arise often in our local area, problems and solutions associated with IPDRE can be shared with both drylands and developing countries, and our regional society. One of our missions is to contribute to the sustainable development of drylands and developing countries in the world as well as our local area through transfer and implementation of knowledge and technologies invented in Tottori University. Industrial Development and Promotion Group of Regional and Industrial Development Project aims mainly to the mission with special emphasis on industrial development and regional

vitalization by taking advantages of our local and international networks. In the present paper, we provide an introduction to the group, our local networks among industry, local government, finance, and academia, joint researches with various sectors, and technology transfer from our university to companies including a local venture company, which is expanding its business in the dryland regions.

**Keywords:** IPDRE, Industrial development, International network, Technology transfer

#### **4. Restoration of the coastal geo-environment along Tottori Sand Dunes**

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Objectives of this study are to trace natural restoration processes of the coastal geo-environment in the humid climate over 50 years along the coast of Tottori Sand Dunes, South-west Japan. Along the coast, dimensions of offshore bars were illustrated from aerial photos taken in 1968-2008 at 5-year intervals, and the grain size distributions at berm crests on the beach have been investigated over a half century since 1955. The results show that beach environments have been restoring naturally after damages induced by human activities, such as sand and gravel harvesting in the Sendai River during 1960-1975, which had caused diminishing of offshore bars, coastal erosions and beach sediment coarsening (>1.0 mm) in 1980's and finally vegetation covering of the Tottori Sand Dunes. After stopping sand and gravel harvesting, large floods occurred in 1998 and 2004. These floods transported lots of sediment from upper parts of the drainage area to the main Sendai River. Around 2000, offshore bars along the coast became larger and grain sizes on the beach changed to become finer (<0.4mm) after 2011. These grain size values are similar to those in 1955. We are expecting that weeds on the Tottori Sand Dunes will regrow naturally by activating blown sand. These phenomena are a good story to let visitors notice: a well-coordinated natural system as a geo-park site in the San'in-kaigan UNESCO Global Geo-Park.

**Keywords:** Natural restoration, Coastal geo-environment, Tottori sand dunes

#### **5. Monitoring aeolian erodibility using synoptic data for preparedness of dust hazard**

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A dust storm is a hazard, which leads to deaths and missing of human beings and animals, and destructions of infrastructures, etc. A dust haze is also a hazard, which causes harmful health effects. One effective way to prevent such damages is evacuation

utilizing an early warning system (EWS). However, the accuracy of numerical dust models, which are employed in many EWSs, is currently insufficient. An occurrence of sand-dust storm depends on the relationship between aeolian erosivity and erodibility. Erosivity is the ability of the wind to cause a sand-dust storm, and it is typically expressed by friction velocity, or simply by wind speed alone. Erodiability is characterized as the susceptibility of a surface to a sand-dust storm, which is influenced by soil and land surface characteristics, particularly the soil particle size distribution, soil water content, vegetation coverage, soil crust, snow cover, etc. Threshold wind speed (TWS) for sand-dust storm is often employed as an index of erodibility, but we have no wide area monitoring system for TWS like surface wind speed monitoring system operating over the WMO synoptic observation network. Many researchers have tried to estimate TWS from erodibility factors. However, monitoring a multitude of erodibility factors is very difficult, and our understandings about the relation between erodibility factors and TWS are insufficient. Therefore, the accuracy of current EWS is still low. We propose a statistically estimated TWS as an index of erodibility, which is calculated from wind speed and present weather observed at meteorological observatories. For an observation that dust occurrence frequency (DOF) increased at many stations in East Asia on April from the 1990s to the 2000s, we discuss its reason in this paper through the results of strong wind frequency (SWF) and TWS, which are indices of erosivity and erodibility, respectively.

**Keywords:** Dust storm, Dust models, Threshold wind speed, Aeolian erodibility

## **6. Soil wind erosion induced by overgrazing and drought in the middle Inner Mongolia, China**

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Grazing induced soil wind erosion is one of the most serious land degradation problems in the arid and semi-arid regions, and it is very typical in the middle Inner Mongolia of China, such as Sonid Zuoqi and Sonid Youqi. Overgrazing can greatly accelerate soil wind erosion, while it can be further exacerbated by abnormal drought events. A lasting and severe drought period was detected since 1999, according to the standardized precipitation evaporation index (SPEI). Soil sampling analysis, comparison of Remote Sensing images and field investigation showed that soil wind erosion processes were very strong and had far-reaching influence on local vegetation and grassland management. Soil wind erosion caused loss or spatial redistribution of lots of topsoil, especially finer soil particles rich in nutrients. As a result, spot-like or stripe-like soil patches were widely distributed around residential areas or along fences, and even randomly scattered in the whole grazing grasslands in the study area. Soil patterns variation severely changed plant community composition and further resulted in

vegetation spatial differentiation. The most obvious cases of strong soil wind erosion are those coarse topsoil layers, bare patches even fully covered by gravels, as well as belt-like sand accumulation with different widths and depths along fences. Simple building fences cannot completely solve the overgrazing problem and thus is resulting in soil wind erosion. Reasonable grazing modes and grassland management means under the context of huge climate variation are still needed in the study area.

**Keywords:** Land degradation, Soil wind erosion, Grasslands, Overgrazing

## **7. Milled *Acacia tortilis* pods and local grass as dry season supplements feed for lactating Goats in the rangelands of Marsabit-Kenya**

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This research on milled *Acacia tortilis* pods and local grass an on-farm feeding trial conducted at Olturot area in northern Kenya. 20 lactating Small East African goats owned by one pastoral producer was used for research. In the trial we set out to understand the nutritional value of processed and none processed *Acacia tortilis* pods and local grass and the influence of these supplements on milk yield of goats and growth rate of kids during the dry season. Whole pods of *Acacia tortilis* with their seeds were ground to form a course mill using a portable manual grinder while local mixed grass hay were chopped and these formed the set of processed feeds. The other feeds (none processed) were whole *Acacia tortilis* pods and long mixed standing grass. A benefit cost ratio (BCR) of the feed supplements was also carried out. The data collected on the chemical composition of feeds and animal performance was analyzed using the Genstat statistical program. We concluded that processing by milling of *Acacia tortilis* pods improved digestibility, while chopping of grass hay increased intake. All supplementation provided net economic benefits, but processing only paid off for Acacia pods. Inclusion in the diet of good quality supplements such as mixed grass hay, milled and whole *Acacia tortilis* pods can alleviate nutritional constraints in the dry season, increase milk yield and sustain the body condition of pastoral goats and improve lively support systems in the arid rangelands of Marsabit County in northern Kenya.

**Keywords:** Goats, Feeds supplement, Local grasses, *Acacia tortilis*, Arid rangelands, Benefit cost ratio

## **8. Enhancement of ABA receptor function confers water-saving drought tolerance in wheat**

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Global climate change has accelerated land degradation among other environmental disorders, which led to massive loss of crop production and may threaten food security in many countries. Especially, drought is the main cause of decreased crop production, thus novel strategies to enhance crop drought tolerance is urgently needed to secure the stable food supply for expanding population. Abscisic acid (ABA) is a plant hormone involved in drought tolerance. ABA inhibits protein phosphatases (PP2Cs), negative regulators in the ABA signaling pathway, by binding to ABA receptor (PYR/PYL). The inhibition to PP2Cs triggers ABA signaling pathway to activate plant drought tolerance machineries. This ABA signaling pathway is commonly found from terrestrial plants, modulating PYR/PYL can be a good option to improve crop drought tolerance. To investigate the effect of emphasized ABA signaling to drought tolerance and the other physiological traits in wheat, we generated the transgenic wheat overexpressing wheat PYR/PYL (TaPYLox). Transcriptome analysis revealed that many ABA responsive genes were induced in TaPYLox even under non-stress condition, referring TaPYLox acquired preemptive drought response machinery with ABA hypersensitivity. TaPYLox presented decreased stomatal conductance and transpiration rate, suggested the enhanced drought tolerance of TaPYLox is based on repressed transpiration with close-prone stomata. Water-use efficiency based on the rate of photosynthesis and transpiration was increased in TaPYLox, while the biomass amount and seed yield produced from 1L of water is significantly increased in TaPYLox. Our study indicates that the enhancement of ABA receptor expression contributes to not only drought tolerance but also the “water-saving drought tolerance” phenotype which can perform highly efficient CO<sub>2</sub> fixation with limited water.

**Keywords:** Climate change, Plant hormones, Physiological traits, Wheat, Water use efficiency

## 9. Potential of tannin-ferrous plants to reduce methane emissions and improve small ruminant production in dry areas

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Small ruminant raising is the main economic activity of agricultural communities in dry areas. These animals often depend on low quality crop residues and expensive feed supplements. The northwestern desert of Egypt is considered as a source of tannin-ferrous plants (TFP) round the year. These plants have a lot of nutritive issues that need to be resolved before depending on them as a good quality fodder. *In vitro* experiments were conducted to evaluate the effect of several mixtures of TFP with urea treated straw (UTS) on dry matter degradation, Ammonia-N and methane (CH<sub>4</sub>) production. Six treatments were examined: Cassava with untreated straw (Trt 1); Cassava plus UTS (Trt 2); prosopis

(*Prosopis juliflora*) plus UTS (Trt 3) ; acacia (*Acacia salicina*) plus UTS (Trt 4); Cassava +Acacia+ UTS(Trt 5); and Cassava+ prosopis + UTS (Trt 6). In addition, twenty-four growing Barki male lambs, aged about 3 months, were used to study the effect of the tested rations on growth performance. The results showed that the condensed tannin (CT) content ranged from 20 g/kg DM (cassava) to 23 g/kg DM (prosopis). Methane production per unit of fermented DM was inversely related to protein solubility. Trt 6 presented a lower ( $P<0.01$ ) ruminal  $\text{NH}_3\text{-N}$  concentration associated with the decreasing ( $P<0.01$ ) in rumen protein degradability. Methane production was highest for Trt1 at all incubation times. After 24 h of *in vitro* incubation,  $\text{CH}_4$  production was 28, 17, 18, 17, 15, and 14 ml, respectively. Daily body gains were significantly affected by tested rations. The highest values were recorded with Trt 6. Consequently, consumption of combination of TFP containing varied classes of secondary components with resource of NPN lead to reducing  $\text{CH}_4$  emissions from ruminants and improving lamb growth performance.

**Keywords:** Tannin-ferrous plants, Methane emissions and Barki lamb growth performance

## 10. STEM Project-based learning in designing and making products for developing countries

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It is generally agreed that education in the fields of science, technology, engineering, and mathematics (STEM) is vital for fostering innovative human resources. To achieve effective STEM education, interdisciplinary and applied approaches are necessary. The four disciplines should be integrated into a cohesive learning rather than teaching each as separate and discrete subject. We introduce the Project-Based Learning (PBL) as a well-suited method to STEM education. In PBL program, students can learn STEM through the experience of project solving interdisciplinarily and practically. Innovation Center for Engineering Education (ICEE) of Tottori University in Japan, provides STEM PBL programs for students in the Faculty of Engineering. In the program, students try to design products and make prototype models under specific subjects. The subjects are offered from collaborating organizations. Usually, they are mainly local companies including NPOs and, sometimes, local governments. So far, educational staff of ICEE have developed and improved the educational programs, instructions, materials and tools. Based on those educational resources, we have just started the new program in cooperation with Jomo Kenyatta University of Agriculture and Technology (JKUAT) of Kenya. In that program, students deal with social problems in Kenya and they work on problem analysis, idea development, product design and prototyping. The cooperating

organization JKUAT presents problems and gives feedbacks to our students. In return, JKUAT can get the outcome of the project. The outcome may be useful as feasibility studies or prototypes. Moreover, the educational methods developed through this program can be applied to develop innovative human resources in JKUAT. Trial classes were conducted using this program. In the trial classes, some students developed a water-filtering system and an animal-detection system. This poster will introduce the details of PBL programs, the results of trial classes with JKUAT and the future plans.

**Keywords:** Project-based learning, Educational methods, Human resource development

## **11. Rapid renewable wood substitute from palm midribs**

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*JEREED* (Arabic expression for rapid renewable wood substitute from palm midrib and trade mark of the organization) uses palm midribs to produce wood-substitute boards, marketable furniture items parquet and decorative accessories to satisfy local, national, and international demands for green products. The machines used are especially designed for production in regular village households, requiring no additional utilities or special investments. This creates income sources for the poor villagers and reduces the negative impact on the environment from burning the palm midribs, or poor maintenance of the palm trees.

**Keywords:** Palm trees, Wood substitute, Farm income, Environmental protection

## **12. New promising cash crop halophytes for dry lands farming**

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Dry areas currently occupy over 40% of the total land surface. These areas are facing a series of challenges: severe fresh water scarcity, land degradation, low agricultural productivity and increasing level of poverty. In addition, the negative effects of these factors would increase as a result of climate change. In our study we have tried to introduce productive new promising cash crop halophytes into cropping systems in the marginal dry areas to raise agricultural productivity and support food and feed security as well as reduce the pressure on limited fresh-water resources. There is no doubt that it will lead to improved quality of life of the rural poor in the dry areas. The newly introduced

plants belong to different families and are: *Sesuvium portulacastrum* (Aizoaceae), *Leptochloa fusca* (Poaceae) and *Chenopodium quinoa* (Amaranthaceae). These plants can grow using land and water unsuitable for other conventional crops, since they are highly tolerant to harsh conditions and have potentials to provide food, fodder, medicines, landscaping and soil covering under conditions of dry regions. The efficiency of such new crops under high saline soil conditions ( $EC_e=27 \text{ ds.m}^{-1}$ ) was evaluated in comparison with normal soil conditions ( $EC_e=1.9 \text{ ds.m}^{-1}$ ). Vegetative growth parameters, productivity, grain yield, proximate analysis and feeding values as well as nutritive values were recorded. The results showed that *Sesuvium* can tolerate and grow under extremely high salinity concentrations. The highest forage yield recorded was  $12.0 \text{ t ha}^{-1}$  with 8% protein content. However, the Na content in *Sesuvium* shoots is 10 times higher than K and P. Concerning chemical compositions of *Leptochloa* shoots, salinity led to an increase in protein, ash, fat and carbohydrates contents, while fiber content was decreased as a compared with non-saline conditions. In quinoa grains the concentration of the total carbohydrates significantly decreased whereas the concentration of protein, Fe, Na and ash increased significantly. No significant differences were found for oil, fiber, P and K contents under saline conditions. These new cash-crop halophytes have high potential as forage crop (*Sesuvium* and *Leptochloa*) and grain crop (quinoa) due to their high nutritional values and quality of grains under dry regions.

**Keywords:** *Leptochloa*, *Sesuvium*, Quinoa, Salinity, Proximate analysis, Feeding values & Nutritive values.

### **13. Defoliation in sorghum and cowpea can increase photosynthetic rate and water use efficiency under drought stress**

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Drought is the major constraint for realizing high crop yields in dry areas. In these areas, because of low soil moisture and high evapo-transpiration demand, the balance of water uptake and transpiration in plant is incommensurate. On the other hand, water uptake is partly determined by the ratio of root length to leaf area (RL/LA). To optimize the balance and enhance the RL/LA, studies have been made to increase root mass, in particular deep roots. The reverse idea to optimize this ratio is defoliation which is excision of the lower parts of leaves. To evaluate the effects of defoliation, grain sorghum (cv. 'Tabat') and cowpea (line 'TVu-7778') were used as the study materials. Two plants of each crop species were grown in a pot filled with sandy soil. At flowering stage (one of the most sensitive growth stages to drought), different levels of soil moisture treatments were set, and non-defoliated 10 plants (control) in each soil moisture treatment were carried into growth chamber. Photosynthetic rate per plant ( $P_{\text{plant}}$ ) was determined by "chamber method" by monitoring air flow rate, and  $\text{CO}_2$  concentration of both input

and output in the chamber. Transpiration rate per plant ( $E_{\text{plant}}$ ) was monitored by weighing each pot continuously. Same measurements were conducted for 20%, 40%, 60% and 80% defoliated plants in each soil moisture treatment. Responses to defoliation were almost similar in both crops.  $P_{\text{plant}}$  decreased with increasing the magnitude of defoliation in wet soil treatments. In dry ones, on the other hand,  $P_{\text{plant}}$  increased with increasing the magnitude of defoliation, that is, with decreasing leaf area. The most appropriate defoliation magnitude was higher in lower soil moisture.  $E_{\text{plant}}$  and physiological water use efficiency ( $P_{\text{plant}} / E_{\text{plant}}$ ) showed almost similar trend with  $P_{\text{plant}}$ . These results suggest that defoliation has the potential to become new appropriate crop cultivation technology in the drylands.

**Keywords:** Drought, Water balance in plants, Root length/leaf area ratio, Defoliation, Cowpea

#### 14. Temperature and precipitation changes in Extensive Hexi Region, China, 1960–2011

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Global change has been evident in many places worldwide. This study provides a better understanding of the variability and changes in frequency, intensity, and duration of temperature, precipitation, and climate extremes in the Extensive Hexi Region, based on meteorological data from 26 stations. The analysis of average, maximum, and minimum temperatures revealed that statistically significant warming occurred from 1960 to 2011. All temperature extremes displayed trends consistent with warming, with the exception of coldest-night temperature (TNn) and coldest-day temperature (TXn), particularly evident in high-altitude areas and at night. Precipitation and rainy days slowly increased with no significant regional trends, mainly occurring in the Qilian Mountains and Hexi Corridor. The significance of changes in precipitation extremes during 1960–2011 was high, but the regional trend of maximum 5-day precipitation (RX5day), the average precipitation on wet days (SDII), and consecutive wet days (CWD) were not significant. The variations in the studied parameters indicate an increase in both the extremity and strength of precipitation events, particularly in higher altitude regions. Furthermore, the contribution from very wet precipitation (R95) and extremely wet precipitation (R99) to total precipitation also increased between 1960 and 2011. The assessment of these changes in temperature and precipitation may help in developing better management practices for water resources. Future studies in the region should focus on the impact of these changes on runoffs and glaciers.

**Keywords:** Climate change, Global warming, Extreme events, China

## **15. Feasibility study on photovoltaic water pumping system for crop cultivation with drip irrigation in the coastal dunes area of Tottori**

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There is abundance of renewable energy resources such as solar and wind in dry lands. The supply of electricity generated from renewable sources for agricultural production makes it possible to decrease the emissions of greenhouse gases from fossil fuels. It also contributes to economic food production. Moreover, the stable supply and effective use of water resources combined with the soil management of farmland is absolutely essential for sustainable food production in dry lands, based on environmental protection. The purpose of this study was to develop the sustainable food production system which is environmental friendly and economically feasible in dry lands. In this study, the photovoltaic water pumping system has been developed at the coastal dunes of Tottori for the crop cultivation using drip irrigation. Field experiment was conducted to investigate the technical feasibility of the whole system in open and a greenhouse located in the Arid Land Research Center, Tottori University in Tottori, Japan. In the field experiment, the saline groundwater is pumped for irrigation by supplying the electricity from photovoltaic power. And then, the saline water is applied for the experiments of salt-tolerant crop cultivation using drip irrigation in the greenhouse. The electricity generation from photovoltaic power, the electric consumption needed to operate the whole system, the supply of irrigation water by the pump, and the meteorological conditions are measured and analyzed through the field test. The effects of quality and quantity of irrigation water, time schedule of irrigation, and type of irrigation tube on growth of crop are also investigated. Finally, the technical feasibility of this system is discussed.

**Keywords:** Irrigation water quality, Photovoltaic water pump, Saline water, Crop growth

## **16. Exploration and practice on the sustainable development of World Heritage Site - a case study of the Mogao Grottoes, Dunhuang, China**

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The Mogao Grottoes of Dunhuang are a world famous treasure of the Buddhist art, located between the Kumtag Desert and the eastern piedmont of Mount Mingsha. Researchers and managers in this site always insist on an all-round sustainable development, including tourism development, cultural inheritance, resource utilization,

cultural heritage conservation, ecology health and environmental coordination. This kind of approach has brought economic and social benefits for the local region. Based on a review of research issues and experiences related to sustainable development of heritage sites, with in the perspectives of environment protection, exploitation and utilization, impact on the economy, we have summarized the status of the development of the Mogao Grottoes, and analyzed the process of sustainable tourism development, identifying the opportunities and challenges in the coming days. After discussion on forging cooperation, an agreement has been reached, between our academy and other institutions for sharing the protection of cultural relics resources. However, there are still many problems, such as the frequent breaking of the limit of maximum tourist bearing capacity fixed considering the fragile ecological environment of grottoes, biodiversity capacity, continued control and monitoring of natural and man-made environment, the landscape change because of infrastructure construction and modification, and the rapid development of heritage sites and buffer zone. The solutions include proper planning, integrated protection and diverse exploration etc., following the principle of preservation and scientific conservation, by real-time environment monitoring, alternated opening of caves, increased technological investment, visitors reservation services and maximum capacity control, scientific management, digital display technology and new media transmission, socialisation of activities of Dunhuang culture, new models of touristic publicity by local residents, and transparent and effective cooperation between all stakeholders. In conclusion, the development of Mogao Grottoes tourism must be based on respecting the ecological environment as well as the local social and cultural environment, by the pursuit of the harmonious development among tourism, nature, culture and human living environment, as a new mode of tourism development that can benefit the future generations.

**Keywords:** Cultural heritage site, Sustainable development, Protection of cultural relics

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