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From the desk of chairman

Dear Readers

Energy, water and food are three major ingredients required for everyday life. Therefore, sustainable management of these resources is highly important. In recent years, the energy-water-food nexus is further challenged by climate change process. Energy demand for meeting the needs for daily life and for the requirement of industrialization has been increasing rapidly. Mechanization in agricultural field and post-harvest processing have also increased the energy demand in agricultural sector. Relying on fossil fuel based energy to meet out these energy demand increases the greenhouse gas (GHG) emissions. Increasing pollution level in atmosphere leads to global warming and shifts in weather pattern. Regions receiving low rainfall are now affected by high intensity rare rainfall events whereas high intensity rainfall zones are becoming drier. Along with this, untimely occurrence of rainfall events cause severe damage to crops affecting the crop production system. Significant shift in occurrence of warmer and cooler periods have also been observed in different parts of the country, which affects the crop calendar for a particular region. Under such situation, it is highly challenging to meet the future food production target of about 1.25 billion population of the country.

Under the climate change context with erratic behavior of rainfall events in dry regions of the country, it is highly essential to manage and utilize every drop of rainwater in crop production system. This issue therefore, discusses a typical runoff farming system, locally known as *Khadin*, existing in very low rainfall (100-200 mm) areas of western Rajasthan. Furthermore, agri-voltaic system, which is recently proposed as an option to double farmers' income by producing food and generating energy from a single land unit by integrating photovoltaic (PV) installation on fragile drylands and practicing crop cultivation in between spaces of PV arrays and below PV module areas is also described this issue. Top surface of installed PV modules in agri-voltaic system are also utilized to harvest rainwater and utilize it further for irrigation of crops and cleaning of PV module. Carbon sequestration is another option to mitigate climate change effect in agriculture and different integrated farming systems for drylands have also been covered in this issue.

I hope the readers will enjoy reading the issue and will be able to gather knowledges on tackling the problems related to energy and water management for sustainable food production system in arid regions.

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Know Your Desert

Runoff Farming System (*Khadin*) in Thar Desert

Khadin, a unique runoff farming system is in vogue in Jaisalmer district since long. This runoff farming system involves collecting and storing runoff water from high-elevation catchment area with shallow soil and underlying rocks in relatively low-elevation areas with deep soil. On withdrawal of monsoon, the accumulated water starts receding due to seepage and evaporation. After recession of accumulated water, *Khadins* are cultivated to grow kharif or rabi season crops depending upon depth of impounded water (Fig. 1). The Jaisalmer district has nearly 34% of geographical area under gravelly and rocky terrain with highly undulating topography and receives 100-200 mm rainfall annually. Therefore, the district offers maximum potential of rainwater harvesting through Khadin system. More than 500 *Khadins* are already under cultivation in different topographical depressions surrounded by *Magra* lands in Jaisalmer, however, these are poorly managed both in terms of utilization of water and selection of suitable crops. For example, during years of high monsoon rainfall, a large amount of water is collected in Khadin bed area from its catchment, which is further allowed to recede for crop cultivation during rabi season. During this process, a large amount of water is lost due to evaporation. Construction of graded *Khadins*, where excess runoff water from upper *Khadin* is released to a lower *Khadin* may be an efficient way to properly utilize stored water during high rainfall events. Conventionally, wheat, chickpea and mustard are major crops in *khadin* bed area during rabi season. However, as per the availability of conserved soil moisture at different sections of *Khadin*, many other crops can be introduced in order to utilise stored soil moisture more efficiently. Although the *Khadin* systems are popular and potential farming system in Thar Desert, possesses enough potential through their efficient management of stored soil moisture.

Fig. 1. View of a *Khadin* during monsoon (left) and Rabi crops (right)

Terrain analysis of a typical *Khadin* from Bharamsar, Jaisalmer revelaed that the bed area for cultivation was about 1/20th of the catchmet area, which was mostly covered by impermeable rocks (Fig. 2). Observations on infiltration characteristics at different places also revealed that, at the crest of rocky catchmnet with high content of sand and gravels steady state infiltration rate was about 205 mm h-1 whereas in bed area it was about 24-35 mm h-1 only (Fig. 3). It indicates that runoff water after passing through the rocky imperable catchment area enters into soil at a faster rate at the crest followed by slow subsurface flow towards *Khadin* bed area along a path of about 1 km, which was hypothesized to continue for about 3-4 months. Therefore, existence of a sufficient path length with gentle slope between the crest of rocky catchment and the bed area of *Khadin* for allowing sufficient subsurface flow may be considered as a criteria for developing new *Khadin* systems in the Thar desert.

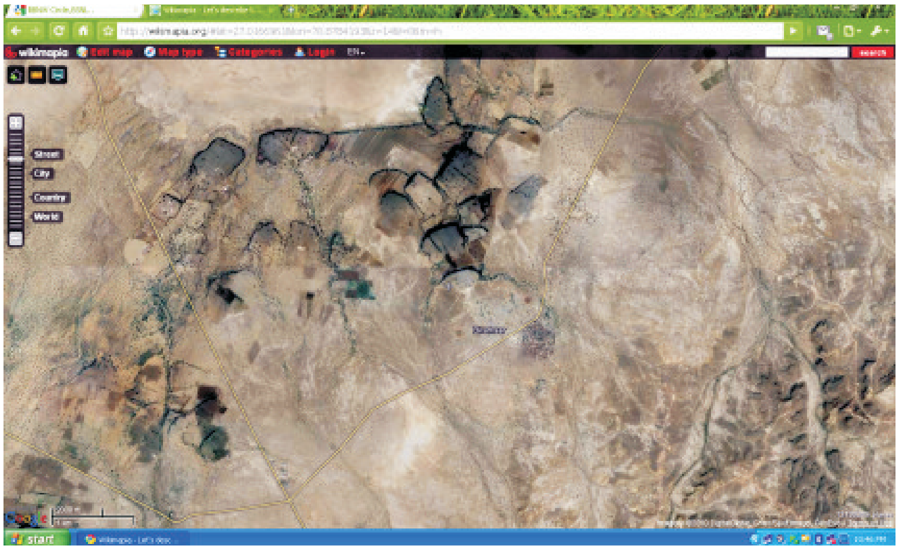

Fig. 2. *Khadin* (runoff farming system) at Bharamsar, Jaisalmer

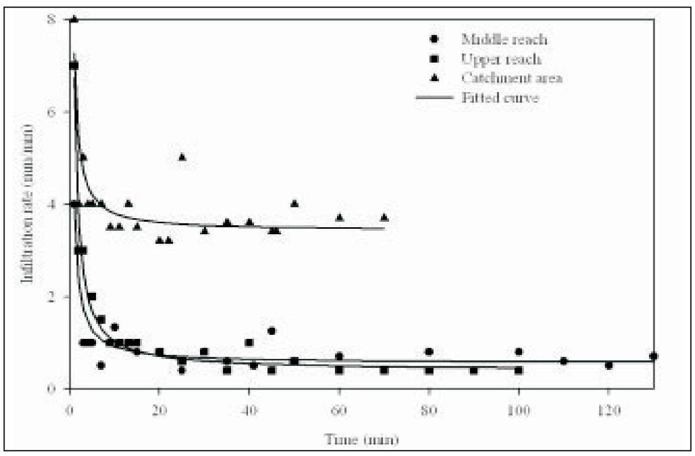

Fig. 3. Infiltration characteristics at different locations within a *Khadin* at Bharamsar, Jaisalmer

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Know Your Desert Plants

Haloxylon salicornicum: A Potential Multi-purpose Shrub of the Thar Desert, India

Shrubs are the integral components of vegetation in Thar Desert. *Haloxylon salicornicum* locally known as Lana is an important shrub species of this region. It belongs to family Chenopodiaceae, and is distributed in north-western Rajasthan between 26 -28° N latitude and 69-73° E longitude comprising Bikaner, Jaisalmer and Srigangangar districts. It occurs mainly in undulating hummocky plains, dune and interdunal plains. *H. salicornicum* is an erect, succulent, dwarf branching perennial shrub with 0.75 – 1.0 m height, and 1.0-2.0 m crown spread. The species has bisexual flower, and propagate via seeds. Flowering occurs during September – October, and fruiting occurs in December–January (Fig. 4). Extremely reduced leaves, thick cuticle, sunken stomata and deep extensive root system are the important adaptive characters of the species which make it to survive under water-limiting environment of Thar Desert.

Fig. 4. Fruiting in *Haloxylon salicornicum*

The species has multiple usages. It is an important feed resource, particularly for camel. Its fruiting tops (locally known as *Fuli*) are nutritious and contain 14-19% protein and 21-24% minerals. The fruiting tops are harvested during November-December and stored to feed the animals during the scarcity period. Feeding trials conducted by ICAR-Central Arid Zone Research Institute, Regional Research Station, Bikaner demonstrated that it can be fed to camel, goat and cattle after mixing with conventional feeds. Its seeds are edible and are mixed with seeds of pearl millet, Sewan grass (*Lasiurus sindicus*), Murath grass (*Panicum turgidum*), and the flour is used for making chapatis. These chapatis are soft, green, tasty and considered as high calorie food during the winter season. The ash of the plant is used as washing agent. The species is used in traditional and folklore medicines for curing internal ulcer, insect stings, cold and diabetes. The ash of the plant is used to control ticks and lice infestations of livestock. A number of bio-active phytochemicals have been isolated from the species. Apart from economic significance, the species has immense ecological values via arresting soil erosion, improving soil quality and the facilitation of herbaceous vegetation. Taking into account of excellent morpho-physiological adaptive characters to survive under desertic conditions along with economic and ecological significances, the *H. salicornicum* is a potential multi-purpose plant species of Thar Desert.

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Technological options

Agri-voltaic System: Option for Doubling Farmers' Income

In order to keep pace with the development there is rise in energy use in every sphere of life including that in agriculture, but it has adverse effects on greenhouse gas emissions due to burning of fast depleting fossil fuels. In this context, there is a need to harness and use more renewable forms of energy, especially solar energy that is plentiful on most part of the country. About 14.8% of energy generation in India is met through renewable sources e.g. wind, solar, biomass etc. whereas coal is still the main source contributing about 60% of total energy generation. During last few years, renewable installed cumulative capacity has increased from 24914 MW in 2011-12 to 50,068.37 MW by the end of December

2016, with an annual growth rate of 17.8%. By the end of December 2016, wind energy installation shares the maximum 28700.44 MW (57%) of total renewable energy installation in the country,where as solar PV installation shares 9012.66 MW (18%). In agricultural sector, energy is directly used for pumping irrigation water, operating different mechanized farm implements/tools and post-harvest processing. With the advancement of food production system from agrarian to a futuristic technology-driven system, there has been rapid increase in energy uses in agriculture. Share of agricultural sector in total energy consumption is about 7-8% and further increase in energy use from its present value of 1.6 kW ha^{-1} to 2.5 kW ha^{-1} is expected to meet the production target of next 20 years.

In view of the future requirement of energy and food production, Agri-voltaic system (AVS) is proposed as a mixed systems associating solar panels and crop at the same time on the same land area. Solar PV modules can be installed in agricultural field for simultaneous generation of electricity and production of food from same piece of land through agro-voltaic system in order to contribute in the national target of 100 GW on-grid PV generations by the year 2022. In the agri-voltaic system, crop production, PV based electricity generation and rain water harvesting can be done on a single farm unit. The agri-voltaic system can be installed in farmers' field where solar irradiation is available in plenty and the local grid network exists nearby farmer's field. The agri-photovoltaic system has very good potential in arid western Rajasthan and Gujarat because of plentiful availability of solar irradiation (5.5-6.0 kWh m^{-2} day^{-1}) in the region as compared to other parts of the country (<5.5 kWh m^{-2} day^{-1}) except Ladakh.

Keeping in mind the importance of agri-voltaic system in future, 105 kW capacity system has been designed and installed at ICAR-Central Arid Zone Research Institute, Jodhpur. The interspace areas and below PV module areas in agri-voltaic system available for cultivation of crops are 49% and 24% of the total block area, respectively. Crops with low height preferably less than 50 cm and which tolerates certain degree of shade and require less amount of water are selected for agri-voltaic system. Green gram (*Vigna radiata*), dew gram/moth bean (*Vigna aconitifolia*) (Fig.5) and cluster bean (*Cyamopsis tetragonoloba*) have been grown in interspace areas of the agri-voltaic system during kharif season whereas psyllum (*Plantago ovata*), cumin (*Cuminum cyminum*) and chickpea (*Cicer arietinum*) have been grown during rabi season. Medicinal plants e.g. Aloe (*Aloe vera*), senna (*Cassia angustifolia*) and Shankshpushpi (*Convolvulus pluricaulis*) have also been grown in agri-voltaic system. Potential crops for below panel areas of agri-voltaic system are turmeric, onion, garlic, water melon, pumpkin, snap melon and leafy vegetables e.g. spinach, coriander, mint etc.

Fig. 5. Moth bean crop at interspace area of the agri-voltaic system at ICAR-CAZRI, Jodhpur

Water harvesting system to collect rainwater from top surface of PV module and to store it in an underground water storage tank has been designed and developed with 105 kW agri-voltaic system. The system has a potential to harvest about 1.5 lakh litre of rain water/year from top surface of PV modules at Jodhpur.

The agri-voltaic system of 105 kW capacity in Jodhpur will generate about 400- 450 kWh unit of electricity per day, which can be sold to local Electricity Board through net metering system. Otherwise, the generated energy can be used as isolated mini-grid to meet the energy demand of the surrounding agricultural lands specifically for pumping and to meet the domestic energy need.

The major potential benefit of agrivoltaic system is the increased income from farm land by selling of PV generated electricity as well as from crop yield and thus has potential in doubling the farm income. Other benefit includes utilization of scarce rain water resources for crop cultivation as well as for cleaning of PV modules, improving the land equivalent ratio, reduction of GHG emission, improvement of microclimates for optimum PV generation and crop production in dry lands etc. Therefore, agri-voltaic system has a great scope in Indian agriculture by providing food-energy-water security and thus may be good option for climate smart agriculture in future (Fig. 6).

Fig. 6. Visit of Sh. Gajendra Singh Sekhawat, Hon'ble Minister of State, Ministry of Agriculture and Farmers Welfare, Govt. of India at the Agri-voltaic System of ICAR-CAZRI, Jodhpur

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Carbon Sequestration in Arid Ecosystem

Integration of woody perennials with arable crops has several economic and ecological significance in arid environment. The significance of agroforestry with regards to Carbon sequestration and other CO_2 mitigating effects is being widely recognized in dry environments. Agroforestry systems involving woody perennials act as carbon sinks due to their ability to sequester atmospheric carbon in deep soil profiles and various tree components. Through proper management, different agroforestry systems (agri-pasture, silviculture, silvipasture, agri-horti) have the ability to remove carbon dioxide from the atmosphere and sequester it in soils and wood products. The carbon thus sequestered can mitigate the emission effect of burning fossil fuels, and could help in reducing the potential impacts of future global warming. Some of the important agroforestry systems and improved practices to sequester carbon in arid ecosystem are discussed.

Silviculture: Silviculture differs from crops and grasslands that the most C is sequestered in aboveground portion of the tree species. On an average forests carbon sequestration ranges from 1.5 to 6.0 Mg C ha^{-1}. The total carbon stock under the sole tree system varied from 3.64 Mg C ha^{-1} in Neem (*Azadirachta indica*) to 6.02 Mg C ha^{-1} in Israeli babool (*Acacia tortilis*) (Fig. 7). The contribution of above ground portions to the total carbon was 80.2-83.6%. However, the above ground contribution in sole pasture to the total carbon stock was 57.3-59.8 %.

Fig. 7. *Acacia tortilis* plantation

Silvopastoral Systems: Silvopastoral systems can play a great role in carbon-sequestration. The trees in the arid zones put forth a large volume of below ground biomass in the form of roots. It is more important in arid zone where climax tree species like Khejri (*Prosopis cineraria*) have very deep root system which can reach upto 70 m depth. Similarly, the shrubs like Phog (*Calligonum polygonoides*) and Lana (*Haloxylon salicornicum*) have more than 2/3rd biomass carbon sequestered in root systems. Thus in arid zones large volume of carbon gets sequestered in lower soil layers, that have high resilience.

When properly implemented, silvpasture can provide many economic and environmental benefits. Planting trees and grasses in degraded lands in arid areas can help in increasing soil carbon stock from 24.3 Pg to 34.9 Pg (1Pg=1015 gram). Compared to sole pasture or sole tree systems soil organic matter, biological productivity and carbon storage were greater in the silvopastoral systems. Silvopastoral systems registered higher carbon stock (4.9-6.8 Mg C ha^{-1}) over sole tree systems (3.6-6.0 Mg C ha^{-1}) or sole pasture systems (1.7-4.3 Mg C ha^{-1}). The silvopastoral system sequestered 36.3% to 60.0% more total soil organic carbon stock compared to the tree system and 27.1–70.8% more in comparison to the pasture system.

Agri-silvicultural system: Khejri (*Prosopis cineraria*) based agri-silvicultural is the most dominant agroforestry system in western Rajasthan, which covers about 47% of the total area. Bordi (*Ziziphus nummularia*) based agroforestry system occupies about 28% of the total area of western Rajasthan. Other systems involving Babool (*Acacia nilotica*), Rohida (*Tecomella undulata*) and Israeli babool (*Acacia tortilis*) etc. occupy about 25% in combine. Study conducted in eight years agri-silviculture systems in arid Rajasthan showed that Aonla (*Emblica officinalis*)+Green gram (*Vigna radiata*) can sequester more carbon (12.7-13.0 Mg C ha^{-1}) as compared to Anjan (*Hardwickia binata*) + Green gram (*Vigna radiata*) (8.6-8.8 Mg C ha^{-1}) and Mopane (*Colophospermum mopane*) + Green gram (*Vigna radiata*) (4.7-5.3 Mg C ha^{-1}) agri-silviculture systems.

Fig. 8. Citrus + Sewan grass in Hortipasture system

Hortipasture: Integration of fruit trees with pasture (grasses and or legumes) in the same unit of land is called as horti-pastoral system. This system acts as one of the economic alternative system for class IV and V type of lands. It can supply the protective food (fruit) for human being and fodder for animals and thus help in bridging the wide gap between the supply and demand of fruit and fodder. Ber (*Ziziphus mauritiana*) based horti-pasture have proved highly remunerative in Thar Desert on farmers' field. Citrus (Fig. 8), Bael and Gonda can successfully be raised under drip irrigation systems and have the carbon storage capacity to the tune of 3.3-8.6 Mg C ha^{-1} 10 years after plantation.

Live fence/wind breaks as boundary plantation

Windbreaks and live fences are two common examples of boundary plantings. Various fodder trees can be planted as live fence to protect the field from animals and other biotic influences. Depending on species used, live fences can in addition provide food, fodder, medicine, fuel wood etc. In arid condition of Rajasthan (India), Bawli (*Acacia jacquemontii*) and Phog (*Calligonum polygonoides*) are the common live fences used for browsing as well as providing economic product. It has even been argued that a field sheltered by a living fence will retain more CO_2 at ground level, to benefit the pasture plants or growing crops which respond with increased yields. They contribute to add organic matter and thus build up humus and sequester carbon in the soil.

Soil erosion control: Grass based systems establish quick ground cover, increase soil resistance against erosion and reduce emissions. The study conducted at ICAR-Central Arid Zone Research Institute (CAZRI), Regional Research Station, Bikaner showed a net loss of 88.2-108.0 kg soil organic carbon (SOC) ha^{-1} in sole cropping system which can be reduced to 80-90 percent under agri-pasture system and completely checked in sole pasture system. Assuming that 20% of the carbon displaced is emitted to the atmosphere, erosion leads to emission of 17-21 kg SOC ha^{-1} y^{-1} due to wind erosion. Grass based systems also prevents the exposure of the sub-soil rich in calciferous materials, which checks the dissolution of carbonates and emission of CO_2.

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Know Your Institutions

Desert Regional Centre, Zoological Survey of India, Jodhpur, Rajasthan

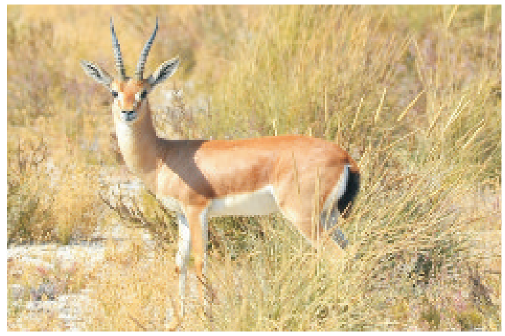
The Desert Regional Centre, Zoological Survey of India, Jodhpur was established in June, 1960 as Desert and Gangetic Plains Regional Station to survey the faunal diversity of Desert Biome. Later, in 1965, it was renamed as at present. The jurisdiction of the Centre is spread over 3,42,239 km^2 area (33 districts) of Rajasthan and 1,81,1000 km^2 (25 districts) of Gujarat. The Centre is engaged in the documentation of the rich and diverse faunal resources of the two states by conducting field explorations and scientific studies.

Major Research Programmes Undertaken by the Centre

Termite Fauna of Gujarat and Rajasthan; Status Survey of Chinkara and Desert Cat in Rajasthan; Studies on Plant and Soil Nematodes associated with crops of economic importance in Gujarat; Fauna of Desert National Park, Rajasthan; Fauna of Sambhar Lake, Rajasthan; Fauna of Pichhola Lake, Rajasthan; Assessment of Faunal Diversity of Nalsarovar Wetland, Gujarat; Faunal Exploration of Tal Chhapar Wildlife Sanctuary, Rajasthan; Fauna of Ranthambore National Park, Rajasthan; Studies on Ants (Formicidae) of Gujarat; Ants (Formicidae) of Rajasthan; Scarabaeidae Beetles of Rajasthan; Scarabaeidae Beetles of Thar Desert of Gujarat; Faunal Exploration of Sariska Tiger Reserve, Rajasthan; Qualitative and Quantitative studies of Plant and Soil Nematodes Associated with Crops of Economic Importance in Rajasthan; Faunal Exploration of Kumbhalgarh Wildlife Sanctuary, Rajasthan; Faunal Survey of Important Congregative Bird Areas (Khijadiya Bird Sanctuary and Marine National Park and Sanctuary) in Gujarat; Diversity of Helminth Fauna of Rajasthan; Vertebrate Faunal Diversity with special reference to Avian and Mammalian Fauna of the Sardar-samand Reservoir, Rajasthan; Studies on Odonata and Lepidoptera Fauna of foothills of Aravalli Range, Rajasthan; Faunal Exploration of Sitamata Wildlife Sanctuary, Rajasthan; Taxonomical study of aquatic nematodes of lakes of Udaipur; Studies on Vertebrate Faunal Diversity of Kachchh Biosphere Reserve (KBR), Gujarat; Exploration of Vertebrate Diversity of Chambal River in Rajasthan State; Studies on Faunal Diversity of Rajasthan - Gaps in Research; Status Survey of *Ardeotis nigriceps* (Vigors, 1831) (Great Indian Bustard) in Grasslands of Rajasthan; Exploration of Ichthyofaunal Diversity in the Escape Reservoirs of Indira Gandhi Nahar Pariyojna (IGNP) Canal in the Bikaner and Jaisalmer districts of the Thar Desert, Rajasthan; Studies on Faunal Diversity of Rajasthan - Gaps in Research; Faunal Diversity of Sariska Tiger Reserve, Rajasthan; Faunal Diversity of Desert Ecosystem, Rajasthan & Gujarat; State Fauna – Rajasthan; Status Survey of Indian Wild Ass (*Equus hemionuskhur* Lesson, 1827) in Desert Ecosystem.

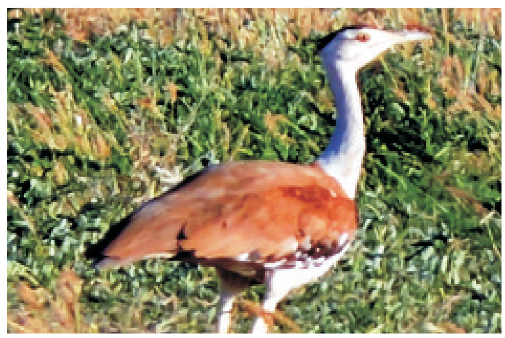
Since its inception, the DRC has been surveying various districts of Rajasthan and Gujarat. The Faunal exploration which includes both extensive and intensive surveys has produced lot of study material representing all the Classes of Vertebrates and most of the orders of Invertebrate phyla. So far 68 species (Acarina, Isoptera, Coleoptera, Hemiptera, Hymenoptera, Thysanoptera, Nematodes and Reptilia) were described as new to science by the scientists of the Centre.

The Centre possesses Taxonomic expertise on Lepidoptera, Hymenoptera, Arachnida, Pisces, Amphibians, Reptiles, Birds and Mammals. The National Zoological Collection maintained at the Centre contain 65,065 identified specimens, including both invertebrates and vertebrates. The centre so far published 28 Books and 775 research papers and provides advisory services on identification to students, researchers and scientists of other institutes. The facilities are also availed by Rajasthan and Gujarat State Forest Department for identification of confiscated specimens of insects, reptiles, birds, and mammals.



***Gazella bennettii* (Sykes, 1831)**

***Panthera tigris* (Linnaeus, 1758)**



***Ardeotis nigriceps* (Vigors, 1831)**

***Saara hardwickii* (Gray, 1827)**

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Knowledge Corner

Arid-lands: Infinite Possibilities from a Finite Resource

Deserts are characterized by their rainfall or rather, their lack of it. Most deserts get less than 250 mm of precipitation each year and evaporation usually exceeds rainfall. Plants, animals and other organisms that live in deserts have evolved to survive harsh conditions, scarce water and barren landscapes. Broadly, a traditional subsistence farming family with 6-8 members, often possess land holding of 6-8 ha with randomly distributed trees like Khejri (*Prosopis cineraria*), Rohida (*Tecomella undulata*), Babool (*Acacia nilotica*) and Kumat (*Acacia senegal*), Jal (*Salvadora oleoides*) few shrubs of Bordi (*Ziziphus nummularia*), Kair (*Capparis decidua*) and occasional grasses like Dhaman (*Cenchrus ciliaris*), Moda dhaman (*Cenchrus setigerus*), Sewan (*Lasiurus sindicus*), Gramna (*Panicum antidotale*) and commonly grows Bajra (*Pennisetum glaucum*), Moth bean (*Vigna aconitifolia*), Mung bean (*Vigna radiata*), Clusterbean (*Cyamopsis tetragonoloba*) and Sesame (*Sesamum indicum*) often in a mixed cropping mode. Such a traditional farming supports 10-12 animals that the family generally possesses. With such farming the family often earns below Rs. 20,000 ha^{-1} which too depends on rainfall. Therefore, rainfed farming despite engaging more than 70% of the total working population, can hardly compete with the income from the business and service sectors, and in present day conditions gradually create an apathy among the inhabitants to plough the land.

But with technological interventions most dramatic changes are taking place now. Modern technology has made settlements in previously uninhabitable regions possible, rehabilitation of areas where settlement and agriculture had been on decline and cultivation of crops in areas where it was not possible earlier. Thus a range of more remunerative crops viz., cumin, isabgol, groundnut, pomegranate, olive, dragon fruits etc. are being grown. Though the present irrigation systems is leading to problems of soil salinity mainly due to overuse of poor quality of water or overuse of water, however further advances in agriculture like implementation of crop location strategies, conversion to higher economic value crops or productivity per unit of water consumed, adoption of alternate drought-tolerant crops, carefully managed deficit irrigation strategies which could be supported by advanced irrigation system and flexible, state-of-the-art water delivery systems would reverse it over a period of time. Further, emerging computerized GPS-based precision irrigation technologies for self-propelled sprinklers and micro-irrigation systems will enable growers to apply water and agrochemicals more precisely with site specificity to match soil and plant status. This would allow farmers to cultivate larger area with the same quantity of water and further improve their economic condition.

A new emerging options to utilize saline ground water of arid lands that are not fit for human consumption or agriculture, for cultivating organisms that can withstand the high content of salt prevalent there. The high mineral content in these waters, along with high ambient temperatures and solar radiation, in fact can support higher primary productivity; forming a suitable and favorable food-base for fish. Success of these systems, however, depend on good water management-such as recirculation aquaculture systems. The desert aquaculture technology does not necessarily require significant investment and can be used for commercial, as well as small-scale affordable aquaculture initiatives. Apart from the farming of table fish, other commercially important and valuable organisms, tolerant to high salt concentrations and high temperatures like small brine shrimp, seaweed and the unicellular green algae, can be produced in arid areas. Currently, Australian farms supply over 60 percent of the world's natural b-carotene extracted from halophile green micro-algae *Dunaliella salina*; which is mainly produced in saline water extracted from tube-wells in South and Western Australia. These systems usually occupy a relatively small area and extremely efficient water usage, with fish production of up to 50 kg/m^3. Apart from Australia, USA, South Africa, Mexico, Qatar, Saudi Arabia, Egypt and Israel have also developed such technologies.

With technological advance large quantity of oil and minerals are being extracted from this land. At present, about 2 million barrels per day of oil is being produced in Barmer making Rajasthan country's second largest oil producing state and with further investment Rajasthan will become India's top oil producing state. Also a refinery is being set up in oil rich

Thar which would strengthen the petrochemical, petro-engineering, petro-medicine research, heating oil industries, polymers, plastics etc. Naphtha is produced from crude oil which is used in the formation of petrol. Simultaneously diesel, kerosene and aviation fuel (gasoline) along with wax, asphalt and other petroleum-based hydrocarbon products will be produced. Whereas oil reserves will eventually run out or may become significantly less profitable if concerns about climate change lead to shift in alternative energy but arid lands of Thar have huge potential to become the largest solar power producer in India. Availability of high levels of sunlight in the area could be utilized by the installation of concentrated solar plant and photovoltaic, to satisfy most of India's energy needs in just few years.

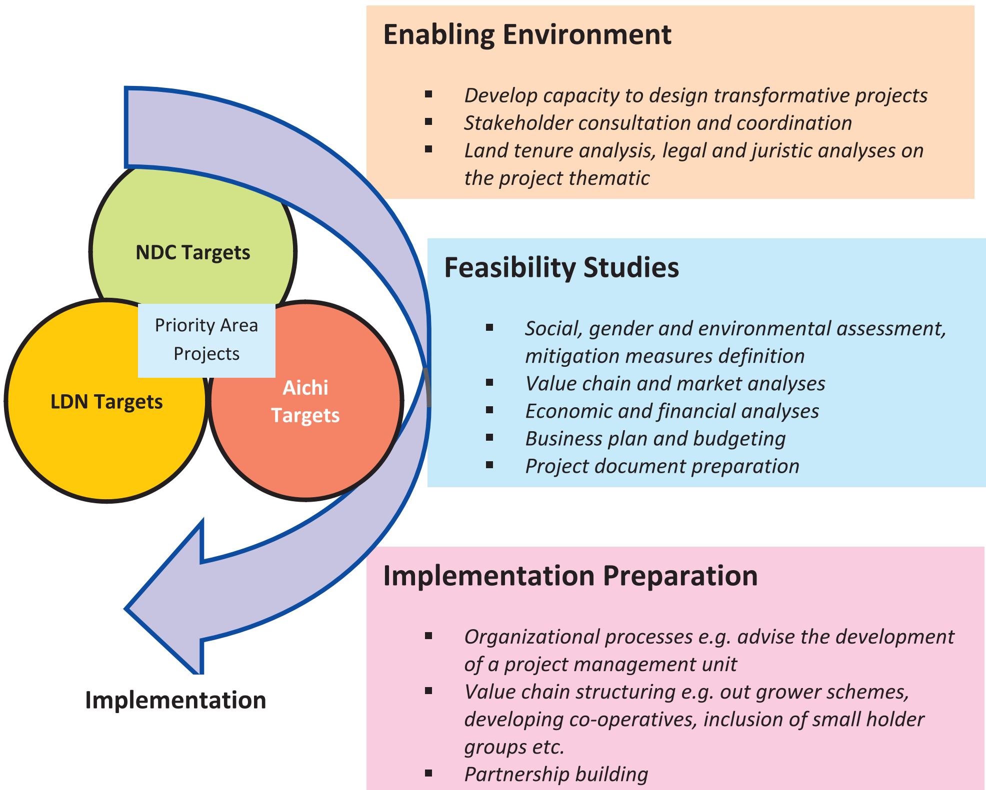
Historically, our relationship with nature has always been one of imbalance and overuse. Nearly every step in human history has unfortunately been accompanied with a leap in environmental degradation. Traditionally the native communities of Thar have remained incredibly in-tune with their surroundings. But with rapid strides in technologyand increasing population, distance between community and nature is growing and these advances have left some adverse tangential effects. Like, drastic changes in nomadic livelihood of the Rabari and Raikas. These shepherds and their families who are used to travelling daily with their camel, goat and sheep, are faced with increasing difficulties as grasslands are shrinking, access to farms is not as easy as it was in the past, and the economic benefits they could earn through this activity are decreasing. Thus, many middle-aged shepherds are selling their herds and going back to their villages, looking for alternative ways of making a living. Younger generations are losing touch with their roots in pursuit of newer dreams and ways of life other than keeping animals and being faced with the same grueling life that their forefathers endured. Also, tourism in the Thar ultimately depends preservation of natural and cultural heritage, being predominantly based on tourist's interest in landscapes, history and archeology. This heritage can be compromised by a number of factors including insensitive development and oil exploration which may threaten number of sites of scientific and archeological interest. Tourism through its own self can cause significant damage to fragile arid environment when it is not carefully managed, through souvenir hunting. Nonetheless, tourism represents a potentially lucrative and sustainable option for many Thar communities. This and other collateral effects of development will be resolved by innovations in future but nagging concerns regarding overuse of arid land resources resulting in their degradation.

Praveen Kumar
ICAR- CAZRI, Jodhpur

Global Resolution in Linking Climate, Biodiversity and Desertification Threats-Recent Approaches

United Nations (UN) calls to address the issues by linking climate, biodiversity and desertification threats through many resolutions during 23rd Session of Conference of the Parties (COP 23) to UN Framework Convention on Climate Change (UNFCCC)-2017. The Executive Secretaries of the Biological Diversity, Climate Change, and Desertification Conventions have called for the establishment of a Facility to secure finance for large projects that will help to address common issues.

Efforts in developing joint global facility: Land productivity is declining as more than a third of land is degraded, with most of it in the last two decades. Current management practices in the land use sector are responsible for approximately 25 per cent of the global greenhouse gas emissions and biodiversity is also disappearing well above the natural rates. With over 1.3 billion people reliant on degrading land and exposed to an unprecedented level of climate stress, the situation is also expected to worsen further. The proposed facility aiming to have two key functions like (i) to deliver on existing commitments by promoting large-scale transformative projects to fill existing gaps between projects and funding; (ii) to act as a catalyst for more coordinated action. The Facility would simultaneously contribute to the implementation of the Aichi Biodiversity Targets of Convention on Biological Diversity (CBD), the Land Degradation Neutrality targets of United Nations Convention to Combat Desertification (UNCCD), and the Nationally Determined Contributions and National Adaptation Plans of United Nations Framework Convention on Climate Change (UNFCCC).The structure and operational details for this facility are expected to be explored in close consultation between the secretariats of the Rio Conventions and potential partners.It is also very special to mention that international community and donors have pledged a number of funding commitments such as the enhanced climate financing to address some of the interconnected issues. However, the existing technical assistance facilities are sector-specific and do not leverage the synergies between land, climate and biodiversity. The ultimate objective of all agreements under the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system, in a time frame which allows ecosystems to adapt naturally and enables sustainable development. Schematic flow system of the implementation is as follows:



Relating Climate Change and Biodiversity: In this context experts state that "Certain kinds of responses to global climate change pose serious risks to biodiversity and ecosystem services, which is why decision-makers need the best-available science when setting policy and allocating resources. Rapid changes in climate can damage ecosystems and accelerate biodiversity loss."

This is one compelling reason to combat global climate change. What is less well understood, however, is how climate efforts with the best intentions – such as limiting the increase in global temperature to 1.50C might also harm biodiversity if not guided by careful analysis. For example, newly-planted forests may help to curb emissions that contribute to climate change – but this can come at the expense of very rich ecosystems like tropical grasslands, if these are seen as appropriate targets for afforestation. Such systems support unique biodiversity and provide important ecosystem services that are not provided by forests. Similarly, while biofuels may generate fewer emissions than fossil fuels, clearing of natural vegetation to make way for biofuel monocultures can reduce carbon storage and extract a high price in biodiversity and ecosystem services.

Stressing the point that biodiversity protection and effective action on climate change are not mutually exclusive, experts also stresses that: "Protecting biodiversity can make substantial contributions to climate change mitigation and adaptation. Reducing deforestation in tropical regions, for example, is a high priority for protecting biodiversity and can make major contributions to climate mitigation, especially when combined with other efforts to reduce emissions of greenhouse gasses. But such objectives may be in conflict with needs to increase food security. New approaches, such as ecosystem-based approaches to adaptation, could help to reduce such conflicts. The bottom line is that policymakers are required to balance several challenges, and need the best scientific evidence to chart the most sustainable course."

This need for policy-relevant knowledge saw Governments at the 2015 UN Climate Change Conference in Paris request the Intergovernmental Panel on Climate Change (IPCC) to provide a special report in 2018 on the impacts of global warming of 1.5 °C. We all are waiting very eagerly for this report to be public during 2018. Sir Robert Watson, Chair of Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and former Chair of the IPCC said: "Successful climate action can never be at the expense of biodiversity, because stabilizing the climate is only possible over the long-term by ensuring the health and protection of biodiversity and ecosystems".

Relating Water and it's action approaches: Water agencies at UNFCCC COP 23 estimate that approximately US$295 billion will be needed for countries to take action on adaptation to climate change in the water sector – a tripling of current investment levels. On the COP 23 Water Action Day, 33 water alliances supporting the integration of nature-based solutions into the Marrakech Partnership for Global Climate Action signed an International Declaration on Nature-Based Solutions for Water Management under Climate Change. Water Action Day at COP 23 featured events and breakout sessions on: water knowledge to respond to climate uncertainty; water for urban resilience; and water for sustainable agriculture and food security. On water financing, Water Action Day speakers noted that most countries have prioritized water in their national climate plans, but financing is far from adequate. They anticipated that approximately 40% of the world's population will face water shortages by 2050, lowering economic output and provoking migration and conflict, and they noted that countries face obstacles in accessing funding to invest in the needed infrastructure and capacity building.

The UN Convention to Combat Desertification (UNCCD) together with the French Water Partnership, International Union for Conservation of Nature (IUCN), the Great Green Wall Initiative and other partners hosted a round-table discussion on the topic. Discussions highlighted the urgency to prepare countries for imminent water shortages through integrated land and water resources management solutions, national drought plans, and working with local communities on environmental restoration. The Ramsar Secretariat hosted a side event focusing on the linkages between water, climate and biodiversity. The International Union for Conservation of Nature (IUCN), suggested that COP 23 should focus more on the role of water in climate action and healthy ecosystems, noting that poor communications and institutional weaknesses are challenges for mainstreaming solutions on sustainable development. The UN Educational, Scientific and Cultural Organization (UNESCO) organized a 'Knowledge Forum on Water Security and Climate Change' in Paris, France, to enhance partnerships for water security and climate change.

COP 23 made progress on framing rules for implementing the Paris Agreement. Developing countries negotiated to have developed countries report, by May 2018, their progress under the Doha amendment. Regarding agriculture, a work plan was proposed by Parties on items related to climate change and agriculture. A few project-specific funding announcements were made, such as for green buildings, power past coal and eco-mobility etc. The key question of when coal will be phased out globally was not addressed. However, 15 countries led by Canada and the UK formed an alliance to cut down their use of coal by 2030. Gender action plan to include women in climate activities has also been considesed. A plan was framed to have indigenous people's opinion and stake in climate talks. An important outcome was the 'Talanoa Dialogue' as a year-long process to assess countries progress on climate actions and under this it was also agreed that the next two climate conferences, in 2018 and in 2019, will have special stock taking sessions.

Dipankar Saha, J.P. Singh and Taru Mathur
ICAR-CAZRI, Jodhpur

Solar Thermal Devices for Farmers of Arid Region

The consumption of energy is increasing with fast growing population and rapid development and it is projected that world conventional energy sources will be exhausted in 50 to 100 years. Since the development of any region is reflected in its energy consumption pattern, it is essential to seek for alternative source of energy. In this context, renewable sources of energy like solar, wind, biogas and efficient utilization of biomass offer considerable advantages to arid region for its sustainable development. India occupies better position in regarding solar energy potential. During the period November to February most of the Indian stations receive 4.0 to 6.3 kWh m^{-2} day^{-1} solar irradiance while in summer season this value ranges from 5.0 to 7.4 kWh m^{-2} day^{-1}. The arid and semi-arid part of the country receives much more radiation as compared to the rest of the country with 6.0 kW h m^{-2} day^{-1} mean annual daily solar radiation received at Jodhpur having 8.9 average sunshine hours a day. Considering such favourable and potentially utilizable available solar energy, several solar energy devices based on thermal technology have been developed in the Division of Agricultural Engineering and Renewable Energy at CAZRI, such as animal feed solar cooker, inclined solar dryer, non-tracking solar cooker, three-in-one integrated devices for drying, cooking and heating, passive cool chamber etc. All these developed devices have been demonstrated in nearby rural areas and have been found to work very efficiently. Moreover, all these devices are environment friendly and also generate income for rural people and therefore has the potential niche in rural economy. Thus, the technologies developed at CAZRI have a great potential for entrepreneurship and food processing in rural areas both off-farm and on-farm level.

Animal feed solar cooker

For boiling of animal feed, huge amount of firewood, animal dung cake and agricultural wastes are burnt using traditional fuel wood stove. Therefore, a low cost high capacity suitable solar cooker has been designed and developed by the institute for boiling of animal feed. The animal feed solar cooker was fabricated using locally available materials e.g. clay, pearl millet husk and animal dung. 10 kg of animal feed can be boiled in a single animal feed solar cooker per day (Fig. 9). The performance of the animal feed solar cooker was further improved by providing an additional reflector during extreme cold days. Crushed barley (*Jau Ghat*), *guar korma*, and *gram churi* with water can be successfully boiled using the animal feed solar cooker between 9 AM and by 3 PM. Animal feed viz., cotton seed and seed cake have also been successfully boiled by the farmers on the solar cooker. Forty units of this animal feed solar cooker fabricated by ICAR-CAZRI have been installed in the villages.

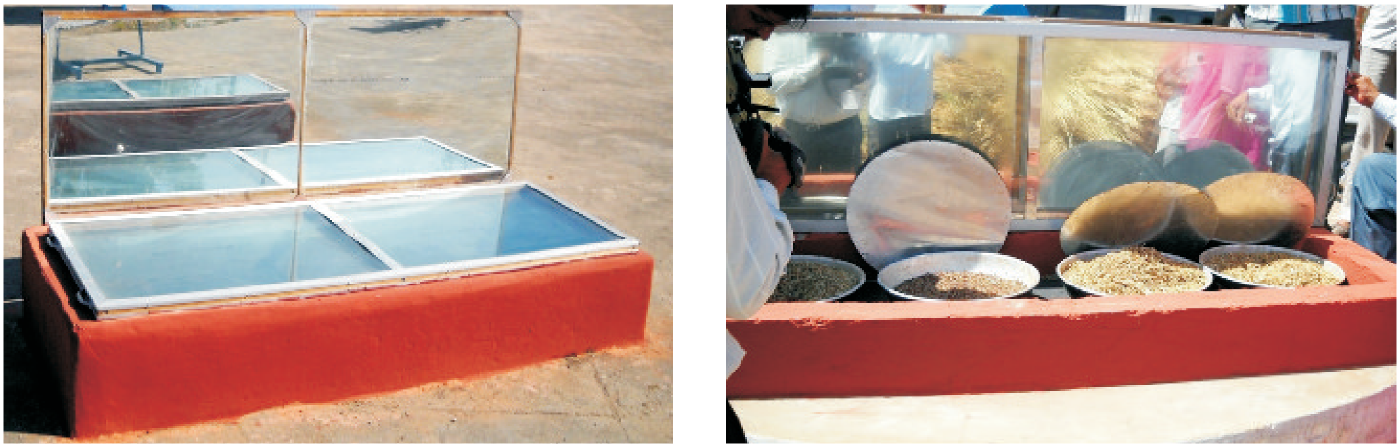


Fig. 9. Animal feed solar cooker

The solar cooker not only saves time of farm women but also saves 1059 kg of fuel wood per year equivalent to 3611 MJ of energy. It is easy to fabricate the cooker at village level at a cost of about Rs. 9000 per unit.Conservation of firewood help in preserving the ecosystem and animal dung cake could be used as fertilizer, which enhances agricultural productivity.

The technology developed for the animal feed preparation not only reduces the greenhouse gas emission but also helps in fuel conservation and drudgery reduction. Moreover, the use of the solar cooker for animal feed would result on the reduction of the release of 1442.64 kg of CO_2 savings/year to the environment and getting Certified Emission Reduction (CER) under Clean Development Mechanism (CDM) mechanism of United National Frame Work Convention on Climate Change (UNFCCC). Meanwhile, money can also be saved, which helps to strengthen the financial status of the marginal rural farmers, if used on regular basis.

Solar dryer

Solar dryer is a convenient device to dehydrate vegetables and fruits faster and efficiently under controlled conditions while eliminating the problems of open courtyard drying like dust contamination, insect infestation and spoilage etc. Among solar dryers like forced, natural, tilted and domestic type. CAZRI designed solar dryers (Fig.10), a low cost tilted type solar dryer, costing about Rs. 9000 per m^2, has been extensively tested for drying onion, okra, carrot, garlic, tomato, chillies, ber, date, spinach, coriander, salt coated amla etc. The powdered products from some of these solar dried materials have been tested for instant use. Local entrepreneurs have adopted such inclined solar dryers of variable capacities (10–100 kg). One can save about 290 to 300kWh/m^2 equivalent energy by the use of such dryers and farmers can accrue higher benefits from solar dried products. The use of the dryer would result on the reduction of the release of 1127 kg of CO_2 savings/year. Solar dried vegetables will be more acceptable in the world market and farmers will get more income.

Fig.10. Solar drier

Surendra Poonia, A.K. Singh, P. Santra and Dilip Jain
ICAR-CAZRI, Jodhpur

Events by ENVIS CAZRI

Visits of GSDP trainees of Zoological Survey of India, Jodhpur

Trainees of Green Skill Development Programme (GSDP) from Desert Regional Centre, ZSI, Jodhpur visited the centre and Desert Botanical Garden of CAZRI, Jodhpur on 16th August, 2017, then got an exposure on medicinal plants, cactus and succulents, rare, endangered threatened and endemic species; grasses, collection of *Aloe vera* germplasm etc. They were also informed about the various activities of the ICAR-CAZRI, ENVIS Centre.

World Ozone Day

World Ozone Day was celebrated on 16th September, 2017 at Krishi Vigyan Kendra, Danta, Barmer. The theme of the Day was "Protecting All Life Under the Sun". Lectures, quiz competition and thoughts of the students were organized on this occasion. About hundred students actively participated and interacted in this event.

Visit of Shri Yashvir Singh, Economic Advisor, MoEF&CC, New Delhi

To coordinate activities related to "Swachhata Hi Seva" Campaign in Rajasthan, Shri Yashvir Singh, Economic Advisor, MoEF&CC, New Delhi visited Jodhpur from 29th September to 2nd October 2017. During these days he graced the programme organized jointly by BSI, ZSI, AFRI and ENVIS, CAZRI and the State Government. He also visited ICAR-CAZRI, Jodhpur and interacted with Dr. O.P. Yadav Director, CAZRI, Jodhpur and CAZRI-ENVIS Team.



Visits of GSDP trainees of Botanical Survey of India, Jodhpur

The trainees of advanced course on Para Taxonomy under Green Skill Development Programme (GSDP), of Arid Zone Regional Centre, BSI, Jodhpur visited ICAR-CAZRI, Jodhpur on 27th December, 2017. The trainees were briefed about the ongoing activities of CAZRI ENVIS and also shown the rare, endangered and threatened plant species of arid region in the Desert Botanical Garden.


Students Visit

Fifty student of M.Sc. Botany from Guru Nanak Dev University, Amritsar visited ICAR-CAZRI, Jodhpur on 29th December 2017. CAZRI-ENVIS Coordinator briefed the ongoing activities of ENVIS Centre on Combating Desertification to the students and faculty.

News

माचिया उद्यान में पर्यावरण अभियान

जोधपुर @ पत्रिका. भारतीय वनस्पति सर्वेक्षण शुष्क अंचल क्षेत्रीय केन्द्र, शुष्क वन अनुसंधान संस्थान, जेडएसआई मरु प्रादेशिक केन्द्र व एनविस केन्द्रीय शुष्क अनुसंधान संस्थान, राज्य सरकार के वन विभाग की ओर से माचिया जैविक उद्यान में जन जागरण अभियान 'स्वच्छता ही सेवा ' जन जागरण अभियान शुरू किया गया। केन्द्रीय पर्यावरण वन और जलवायु परिवर्तन मंत्रालय की ओर से यह अभियान 15 सितम्बर से शुरू किया गया था, जो 2 अक्टूबर तक पूरे भारत में आयोजित किया जाएगा। केन्द्रीय पर्यावरण वन और जलवायु परिवर्तन मंत्रालय के आर्थिक सलाहकार यशवीरसिंह और मुख्य वन संरक्षक आरएस शेखावत ने पौधरोपण कर अभियान शुरू किया। अभियान में जोधपुर शहर के विभिन्न विद्यालयों के विद्यार्थियों ने माचिया जैविक उद्यान से कायलाना झील परिसर की सफाई की। कार्यक्रम का संचालन डॉ. संजीवकुमार ने किया। शनिवार को गुड़ा विश्नोइयां के वन्यजीव बहुल क्षेत्र में वनविभाग के सहयोग से क्षेत्रवासियों को पर्यावरण के प्रति जागरूकता का संदेश दिया गया।

पत्रिका Sun, 01 October 2017 epaper.patrika.com//c/225634

काजरी में किया शोध कार्यों का जायजा

बासनी (जोधपुर). काजरी में शनिवार को राजमाता विजयराजे सिंधिया कृषि विश्वविद्यालय ग्वालियर के कुलपति डॉ. अनिलकुमार सिंह और केन्द्रीय पर्यावरण वन एवं जलवायु परिवर्तन मंत्रालय के आर्थिक सलाहकार यशवीर सिंह ने शोध कार्यों का अवलोकन किया। विभिन्न किस्मों की लहलहाती फसलों को देखकर इन्हें किसानों तक पहुंचाने की जरूरत बताई। उन्होंने नर्सरी में उत्पादन व कुम्मट से गोंद प्राप्त करने की तकनीक की भी सराहना की। काजरी निदेशक डॉ. ओपी यादव ने फलदार एवं अन्य पौधों की मांग व आपूर्ति, बीज उत्पादन, सौर ऊर्जा प्रणाली, जल संग्रहण, उन्नत टांका, फलों में मूल्य संवर्धन, थार पारकर गायों की उपयोगिता जैसे विभिन्न कार्यों की कार्यप्रणाली से अवगत करवाया तथा शोध कार्यों से किसानों को अधिक फायदा पहुंचाने का भरोसा दिलाया।

पत्रिका Sun, 01 October 2017 epaper.patrika.com//c/2256

ओजोन दिवस पर कार्यक्रम आयोजित

बाड़मेर | काजरी मरुस्थलीय पर्यावरण सूचना केन्द्र जोधपुर द्वारा कृषि विज्ञान केन्द्र दांता में विश्व ओजोन दिवस का आयोजन किया गया। जिसमें काजरी के प्रधान वैज्ञानिक डॉ. जे.पी. सिंह ने ओजोन परत के महत्व के विषय में कहा कि हमें ओजोन परत के क्षरण को रोकने के प्रभावी प्रयास करने की जरूरत है ताकि इससे होने वाली हानि को कम किया जा सके। उपनिदेशक कृषि किशोरीलाल वर्मा ने विद्यार्थियों को ओजोन परत से होने वाले नुकसान के बारे में बताया। डीडीएम नाबार्ड डॉ. दिनेश प्रजापत,वरिष्ठ वैज्ञानिक डॉ. प्रदीप पगारिया ने बाड़मेर जिले के परीपेक्ष्य में होने वाले जलवायु परिवर्तन पर विस्तार से चर्चा की।

Conferences

Date	Topic	Place
	International	
July 23-27, 2017	International Congress for Conservation Biology: "Insights for Sustaining Life on Earth"	Cartagena, Colombia. Organized by: Society for Conservation Biology
November 6-9, 2017	International Conference on Drylands, Deserts and Desertification	Ben-Gurion University of the Negev, Israel.
December 6-9, 2017	Expert Workshop on Invasive Alien Species in Preparation for the twenty-second meeting of the Subsidiary Body on Scientific, Technical and Technological Advice.	Montreal, Canada and Organized by: Secretariat of Convention of Biological Diversity.
	National	
September 19-21, 2017	Alternate Farming System to enhance Farmer's income	YSP University of Horticulture & Forestry, Nauni 173 230, Solan, HP
October 1, 2017	National Conference on Advances in Science, Agriculture, Environmental & Biotechnology (NCASAEB)	Jaipur, India
December 12-14, 2017	6th International Conference on Advances in Energy Research 2017	IIT-Bombay, Mumbai