Foreword

The diverse challenges and constraints emerging from growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

Agriculture today is facing competition for good quality land and water resources from domestic and industrial sectors. Nearly 6.73 million hectares of agricultural land is affected by varying degrees of salt problems and represent a serious threat to food production to meet the needs of the country. The estimates indicate that by 2030 the country may have about 15.5 million ha area under salt affected soils. There is, therefore, an urgent need to have comprehensive understanding and better contingency plans based on resource efficient, socio-economically viable and environmentally safe technologies to deal with salt degraded soils and to improve productivity of such marginal lands. The Central Soil Salinity Research Institute (CSSRI), Karnal has developed several technologies to support agriculture on saline areas but has several challenges ahead.

It is expected that the analytical approach and forward looking concepts presented in the ‘Vision 2030’ document will prove useful for the researchers, policy makers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

30 June, 2011
New Delhi

(S. Ayyappan)
Secretary, Department of Agricultural Research & Education (DARE) and Director General, Indian Council of Agricultural Research (ICAR)
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Central Soil Salinity Research Institute (CSSRI) is the premier research organization dedicated to pursuing interdisciplinary research on salinity management and use of poor quality irrigation waters in different agro-ecological zones of the country. Since its establishment in 1969, the success of CSSRI is evident from the rapid spread of reclamation technologies which helped in wide spread adoption of alkali soil reclamation package. It is estimated that about 1.8 million ha of salt affected area has been reclaimed by the adoption of technologies developed by CSSRI. This area alone is contributing nearly 15 million tonnes of paddy and wheat annually besides generating on-farm and off-farm jobs for more than 210 million person-days during the last three decades. Over the years, the Institute has grown into an internationally recognized esteemed center of excellence in salinity research.

The problems of soil sodicity, salinity and of poor quality water are likely to increase in the near future due to planned expansion in irrigated area and intensive use of natural resources to meet food, fodder, fibre and timber requirement of the burgeoning human and livestock populations. Tentative estimate is that the salt affected soils will constitute about 15.5 million ha area in the country by 2030.

The present document, CSSRI Vision 2030 is an output of the joint effort by large number of dedicated scientists and embodies the valuable suggestions from the Chairman and Members of RAC and QRT of the institute. This document represents our thinking, not only on what needs to be done, but what can be reasonably achieved by the year 2030 by pursuing the research agenda in a network participatory mode with national and international organizations.

I would like to express my gratitude to Dr. S. Ayyappan, Secretary, Department of Agricultural Research & Education (DARE) and Director-General, Indian Council of Agricultural Research (ICAR), New Delhi for his invaluable guidance in preparing CSSRI Vision 2030. I am grateful to Dr. A.K. Singh, Deputy Director General (NRM), ICAR, New Delhi for his personal interest and guidance during the preparation of this document. I express my sincere thanks to Dr. P.S. Minhas, ADG (S&WM); Dr. S.S. Khanna, Chairman, QRT; Dr. Pratap Narain, Chairman, RAC; and
Dr. R.S. Rana, Member, QRT for their valuable suggestions and critical comments, which guided us in bringing the document to its present form.

I appreciate the efforts of Dr. P. Dey, Dr. S.K. Gupta, Dr. P.C. Sharma and all the Heads of Divisions and Stations in bringing out this Document. I am confident that CSSRI Vision 2030 would provide a direction to research on salt affected soils and poor quality waters.

30 June, 2011
Karnal

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Agriculture sector is facing an unequal competition for good quality land and water resources from domestic and industrial sectors so much so that future agriculture will increasingly be pushed to marginal environments. While water will turn out to be a major constraint in increasing agricultural production, increasing problems of salinity and waterlogging would also adversely affect agricultural production and productivity. Therefore, it would be imperative to have excellent inventories on salt affected soils and poor quality waters. Moreover, it would be paramount to develop and adopt preventive strategies to check spread of waterlogging, cheaper options for reclamation of alkali soils through the biological route, scientific water management practices, viable drainage techniques, varieties with multiple tolerance to biotic and abiotic stresses and heavy elements, eco-friendly options for use of urban waste waters and location specific technologies for sodic Vertisols, soils with surface drainage congestion, high water table and indurated pan at shallow depth and coastal saline areas.

During the last few decades, alkali soils reclaimed using CSSRI technologies have contributed considerably to the food security system of the country. Therefore, we need to prioritise our actions to facilitate the adoption of alkali soil reclamation technology under resource constraint situations so as to reclaim the left over alkali lands. Breeding work, aiming at developing more salt tolerant high yielding varieties, would provide alternate technologies to suit different resource endowments of the farming communities. Due attention needs to be paid to sustain the productivity, fertility and soil health in post-reclamation phase. For waterlogged saline soils, subsurface drainage technology developed by CSSRI initially for Haryana has been widely adopted and replicated in the states of Rajasthan, Gujarat, Punjab, Andhra Pradesh, Maharashtra and Karnataka. Involvement of the stakeholders from the beginning, sharing of construction and operational costs and government subsidy are vital to the success of this technology. In recent years, biological systems (bio-drainage) and land modifications are being advocated as an alternative to conventional land drainage to effectively utilize waterlogged salt affected soils. Since the interaction between soil, water and vegetation is extremely complex and is compounded by soil heterogeneity, nature of vegetation and environmental conditions, systematic studies
on the quantification of their impact on salinity and waterlogging control are lacking. We would strive to fill-up this gap.

Proper management of water is crucial if we are to protect our irrigated area from secondary salinization and save the enormous investments made in developing the irrigation potential. Indiscriminate use of poor quality waters in the absence of proper soil-water-crop management practices pose grave risks to soil health and environment. While the principal agricultural water quality constituents such as salinity, sodium, nitrate, trace elements, boron, selenium, arsenic, pesticide residues, sediments and water quality guidelines need a fresh look, heavy metals have also become important for using polluted water. To facilitate adoption of more efficient micro-irrigation systems, salinity and sodicity tolerance limits of crops, horticultural and forest species need to be worked out for application under these systems. Wastewater would be one of the most reliable sources of water in the 21st century. Domestic wastewater could also meet a part of the nutrient requirement of the crops. Bio- and phyto-remediation are viable techniques for treating sewage and other urban effluents. Role of microbes for detoxifying salt and heavy metal loaded soils and waters also need to be exploited. Awareness generation and sensitization of the farmers and effective formulation and implementation of water policies by the government would be needed for which CSSRI would provide the necessary inputs.

Technology transfer, identification of gaps under farmers’ resource endowments and impact assessment are essential components in the successful adoption of any technology. Actions for human resource development would be reoriented to meet the increasingly sophisticated needs of the emerging situations. Efforts in transfer of technology could be hampered by bottlenecks of varying kinds at different stages of implementation. These would be diagnosed and corrected speedily. Besides, participatory approach will be pursued to efficiently transfer the technologies.

We are in the process of preparing the XII plan document. Preparation of vision document at this stage has given us an opportunity to look back as well as to identify the future agenda for resolving basic and applied research issues. A brief discussion on many such issues has been included in the forthcoming sections of this document. As such, ‘CSSRI Vision 2030’ presents a roadmap to food and nutritional security of India using salt affected soils and poor quality waters as an opportunity. This document provides a way-forward towards achieving high productivity under marginal land and water environments which would help us in ushering into the second green revolution.
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Ever increasing demand for good quality land and water resources in the domestic and industrial sectors has resulted in enhanced interest in the utilization of salt affected soils and poor quality waters for food production to feed the teeming millions. As per the projections made, an area of about 15.5 million ha is likely to be affected by the problems of waterlogging and soil salinity in the irrigation commands of India by 2030. This does not take into account the area under non-commands (lift irrigation schemes), coastal salinity and salinity in ground water irrigated land with deep water table. The soil salinization and poor quality waters have caused huge direct and indirect losses. For example; waterlogging, soil salinity and saline groundwater conditions at shallow depth in Haryana alone are resulting in a potential annual loss of about US$ 37 million at 1998-1999 prices (CSSRI 1997). Similarly, waterlogging and soil salinity increased at an average rate of 3000 ha per year during 1984-2000 in the Tungabhadra command resulting in an economic loss of Rs. 250-300 million per year in crop production alone.

To have a concise and reliable estimate of salt affected soils in India besides their easy retrieval, mapping of salt affected soils for 15 states of India has been completed and the maps on 1:2,50,000 scales have been digitized. Based on these maps, total salt affected area in the country has been computed to be 6.73 million ha. For practical applications, maps on 1:50,000 scale would be prepared in future.

Alkali land reclamation technology through chemical amendments developed by CSSRI has by now become quite popular. It is estimated that about 1.8 million ha of alkali lands have been reclaimed by the adoption of this technology. Farmers could obtain 4 t ha⁻¹ rice and 2 t ha⁻¹ wheat yields in reclaimed alkali land in the first year of reclamation, which increased to 5 and 3 t ha⁻¹ respectively during 3rd year onwards. On this basis, reclaimed area alone is contributing approximately 15 million tonnes of paddy and wheat.
annually. Besides, it has generated on-farm and off-farm employment for more than 210 million person-days during the last three decades. Alkali land reclamation activity in the last 42 years generated one time employment of about 25 million person-days in the first year of reclamation. In addition, it now generates an annual employment of 75 million person-days each year for rice-wheat cultivation on the reclaimed lands. It has been proved that technology is economically viable with its Net Present Worth (NPW) at Rs. 56,000 ha⁻¹, Benefit Cost Ratio (BCR) at 1.52 and Internal Rate of Return (IRR) at 21.40%. The technology improves soil health, increases resource use efficiency, raises farm income, reduces poverty, minimizes inequity, reduces flood hazards and water logging, recharges ground water besides improving quality of overall environment. Since the availability of gypsum in adequate quantities is doubtful and the cost of alkali soils reclamation at constant prices is rising, the need to explore alternate technologies like biological reclamation using microbes, application of organic materials like green manures, FYM, crop residues, enhancing efficiency of other amendments like pyrites, industrial by-products such as distillery spent wash and diversification into silvi-pastoral systems will assume greater significance. Development of crop varieties capable of being cultivated with no or reduced dose of amendments will be an attractive biological reclamation option.

Subsurface drainage technology initially developed for Haryana has been widely adopted and replicated in Rajasthan, Gujarat, Punjab, Andhra Pradesh, Maharashtra and Karnataka. More than 50,000 ha waterlogged saline soils have been reclaimed in different states of India. It had remarkable impact on crop yield, farm income and employment. The cropping intensity increased by 25 to more than 100% and crop yields by 45% (paddy), 111% (wheat) and 215% (cotton). The technology generated around 128 person-days additional employment per ha per annum. Its NPW was estimated to be Rs. 45,000 ha⁻¹, BCR 1.46 and IRR 13%. The technology reduced flood hazards and waterlogging, improved resource use efficiency, reduced poverty, minimized inequity and improved quality of life of the people in the affected areas.

In many states and more so in Punjab, Haryana and Uttar Pradesh, sustainability of irrigated agriculture has been threatened due to alarming decline in water table. The declining water table has increased pumping costs and has adversely impacted the environment. CSSRI has developed, installed and evaluated individual farmer based groundwater recharge structures at more than 90 farmers’ fields in alluvial regions of Haryana, Punjab, Uttar Pradesh and Gujarat. These structures are based on well injection techniques and involve passing of excess rain and canal water under gravity...
through tube well type recharge structures to suitable aquifer (sandy zones) after filtration through a recharge filter. The recharge structures have proven highly effective in augmenting groundwater, improving its quality (salinity, alkalinity and fluoride concentration) and enhancing farmers' income by saving submerged crops by recharge of excess water. The payback period of 30- 45 m deep recharge structures has been estimated to be 1- 2 years only.

The institute prepared and published the first approximation water quality map of India. For the sustainable use of poor quality waters in agriculture, the institute has developed new technologies like treating of sodic water with gypsum, pyrite and distillery spent wash, blending of poor quality water with canal water, cyclic irrigations with good and poor quality waters and pitcher irrigation etc. Out of present ground waters development of 13.5 million ha-m per year, poor quality waters account for 3.2 million ha-m per year. A rough estimate of its contributions in food grain production is expected to the tune of Rs. 8000 million. Increased utilization of saline ground waters generated employment opportunities since lands otherwise kept fallow could be cultivated with saline water. Estimates in this regard are about 55 million person-days of employment per year.

According to an estimate, India would experience 40% productivity decline by the year 2080 due to climate change. It is higher than Africa and Latin America where yield reduction would be about 30 and 20% respectively. The rise in sea level due to global warming is expected to increase waterlogged and salt prone areas. Such emergent situations calls for the development of more submersion and salt tolerant varieties of crops. Sustained breeding efforts at CSSRI have resulted into the development of high yielding, salt tolerant varieties of rice (CSR 10, CSR 13, CSR 23, CSR 27, CSR 30 and CSR 36), wheat (KRL 1-4, KRL 19, KRL 210 and KRL 213), Indian mustard (CS 52, CS 54 and CS 56) and chick pea (Karnal Chana 1). Rice variety CSR 30 is long grained and basmati type whereas Indian mustard variety CS 56 is suited to late sown irrigated conditions besides having salt tolerance characteristics. Further efforts are needed in this direction to design platforms for crops where genes such as Saltol and Sub1 can be impregnated in the high yielding leading varieties to strengthen these characters.

For the reclamation of highly deteriorated, mainly community lands, an augur hole technology has been developed and standardized for raising forest and fruit tree plantation. This technology comprises of making auger holes to break hard kankar layer beneath the soil by a tractor driven auger, filling the pits with gypsum/nutrient mixture followed by seedling transplantation. By adopting this technology, state forest
departments have raised successful tree plantations on salt affected village community lands and Govt. lands adjoining roads, railway lines and canals etc. It is assessed that different agro-forestry models helped to reclaim 60,000 ha land. This contributed significantly in augmenting fuel wood and forage needs of landless labourers and small farmers and increased forest cover besides sequestering carbon to moderate the impact of climate change.

Large quantities of wastewater generated in urban areas are being used indiscriminately as raw or with little treatment for irrigation to grow food crops including vegetables with no concerns for the contamination of natural resources and the food chain. Treating these wastewaters up to the desirable levels before disposal is a costly affair and prohibitively expensive for developing countries. Their disposal in forestry plantations or non-edible crops having high transpiration rate and producing huge biomass can be considered safe. Plants like *Eucalyptus* especially clones like *Bhadachallam* may consume water luxuriously if available in plenty because of high transpiration rates. Other options for safe wastewater disposal like cultivation of industrial crops, aromatic grasses or flower crops producing high biomass with non-edible economic parts have also been tried. Studies on their effects on ecosystem, the relationships between rate of disposal, carrying capacity of plantations and soils, depth of aquifer, climate and quality of wastewater in question are needed to arrive at a logical solution to the complex problem.

Uttar Pradesh and Bihar have about 1.52 million ha of salt affected areas with many distinct characteristics like surface drainage congestion, high water table, relatively heavy textured soils, indurate pan at shallow depth and high degree of variability in soil sodicity within the field. These soils, if reclaimed, offer enormous scope to enhance crop production in these states. Besides, there is a need to develop strategies to improve water productivity through farming system approach in irrigation commands in general and more so in the Sharda Sahayak Canal command. Efficient, balanced and integrated use of inputs including amendments and fertilizers, minimization of reclamation cost, resource conservation, participatory varietals selection and improvement in crop production through the use of salt tolerant varieties are some of the strategies that have been put in place and have proved beneficial. There is a need to develop alternate land use system. With growing shortage of fresh water supplies, strategies for using contaminated water with arsenic and fluoride also need to be developed.

About 2.22 million ha area in Gujarat state alone has gone out of cultivation due to waterlogging and salinity. With the advent of new irrigation projects and likely use of irrigation water in business as usual mode would further aggravate the problems in the
region. Since installation and maintenance of drainage system is costly, evolving ideal soil and water management strategies seems promising to help in the restoration of affected lands to their original productivity. Evolving or identifying salt tolerant plants as an alternate land use for the utilization of such problematic soils seems reasonable. Highly saline soils can be utilized through salt tolerant grasses and halophytes for economic production of fodder, fuel and other products. The domestication of halophytes has been proposed as a strategy to expand cultivation on unfavourable lands like saline black soils. In the saline black soils of the coastal areas, high rainfall and impeded drainage contribute to the waterlogging problems. The possibility of rising seawater level due to global warming would further aggravate the problem of seawater intrusion/inundation in the region leading to salinization of the coastal and inland areas. In coastal region, proper rainwater harvesting coupled with low water requiring crops would ease the problem. Ground water too saline for irrigating conventional crops can be effectively used to grow economically potential salt tolerant plants and halophytes of economic value. Biosaline agriculture could play an important role in the coastal areas. Majority of the industrial units that lie in the Golden Corridor, i.e. Vapi-Mehsana region, produce huge quantities of treated effluents and solid waste as biological sludge. Concerted efforts are needed to formulate strategies for its effective use in agriculture to save irrigation water and to minimize the use of chemical fertilizers.

The coastal agro-ecosystem of India occupies an area of about 10.78 million ha along the 8,129 km coastline (Velayutham et al., 1998). The coastal eco-regions of India are marked as one of the traditionally backward and disadvantaged areas with low agricultural productivity. The farming community is dominated by poor, marginal and landless farmers with abject poverty, and the land holdings are generally small and fragmented. The cropping pattern is predominantly mono-cropped with low yielding traditional rice varieties in wet season. Agriculture and allied activities are the major livelihood of the people but the productivity is usually very low as it is hindered by cluster of problems such as degraded soils (saline, alkaline, acid sulphate, deep waterlogged, flood prone, and poorly drained), abundance of brackish water unfit for irrigation, climatic constraints and weather hazards. The area is otherwise normally endowed with rich biodiversity. The recent threat of sea level rise due to global warming has further aggravated the miseries of people living in the coastal areas and the trend may be on the increase in future. Of significant importance is the threat to the very stability of the ecosystem for which a large number of factors besides climatic change are responsible. It has, therefore, been the endeavor of CSSRI to take research initiatives to address the problems of coastal ecosystem. Some of the technologies
include: on-farm water harvesting structures to improve drainage and to facilitate double cropping, aquaculture, management of acid sulphate soils, integrated nutrient management, improved dorouv technology to skim fresh water floating on the saline water, reclamation of abandoned aqua ponds, land modification, variety development for deep and medium surface water stagnation during monsoon season etc. These technologies would go a long way in alleviating the poverty commonly witnessed in the coastal areas.
THE Government of India constituted an Indo-American team to assist the Indian Council of Agricultural Research (ICAR) in developing a comprehensive water management programme for the country. As a follow up of these recommendations, it was decided to establish the Central Soil Salinity Research Institute as a Fourth Plan Project. The Institute started functioning at Hisar (Haryana) on 1st March 1969. As per recommendations of the Committee constituted by Director General, ICAR, it was decided to shift the Institute from Hisar to Karnal in October 1969.

In February 1970, the Central Rice Research Station, Canning Town, West Bengal, which was formerly a part of the Central Rice Research Institute, Cuttack was transferred to the CSSRI. A Regional Research Station of the CSSRI for carrying out researches on problems of inland salinity prevailing in the black soil regions in the western parts of the country started functioning at Anand in Gujarat from Feb. 1989. As per recommendations of the QRTs, the Council shifted the station from Anand to Bharuch. It started functioning at the later site from April 2003. Keeping in view the need of undertaking research for situations under surface drainage congestion, high water table conditions, relatively heavy textured soils, and indurated pan, another Regional Station of the CSSRI was established on 27th October, 1999 at Lucknow (Uttar Pradesh).

Besides, the coordinating unit of the All India Coordinated Project (AICRP) on the Management of Salt Affected Soils and Use of Saline Water in Agriculture is in operation at the institute. It has a network of eight research centers located in different agro-ecological regions of the country (Agra, Bapatla, Bikaner, Gangawati, Hisar, Indore, Kanpur, Tiruchirrapalli).

**Mandate**

- To undertake basic and applied researches for generating appropriate agro-chemical/ biological/ hydraulic technologies for reclamation and management of salt affected soils and use of poor quality irrigation waters for sustainable production in different agro-ecological zones
- Evolve, evaluate and recommend strategies that promote adoption of preventive/ameliorative technology
- To act as repository of information on resource inventories and management of salt affected soils and waters
- To be a nucleus of researches on salinity management and co-ordinate/support the network of research with universities, institutions and agencies in the country for generating and testing location-specific technologies
- To act as a centre for training in salinity researches in the country and region and provide consultancy
- To collaborate with relevant national and international agencies in achieving the above goals

Central Soil Salinity Research Institute is the premier research organization dedicated to pursuing interdisciplinary research on salinity management and use of marginal quality irrigation waters in different agro-ecological zones of the country. Over the years, the Institute has grown into an internationally recognized esteemed center of excellence in salinity research. Multi-disciplinary research activities at the main institute are being strengthened through four research divisions. The major research activities in the Division of Soil and Crop Management include preparation and digitization of database on salt affected soils besides periodic assessment of state of soil resources, developing technologies for the optimal management of gypsum amended alkali soils and the use of high RSC and saline waters for crop production. In the post-reclamation phase, focus is on developing resource conservation technologies and the development of farming system models for resource poor farmers owning 2 ha or less land. Agro-forestry is another area of focus besides the production and evaluation of bio-fuel and bio-energy efficient plants from salt affected soils. Development of regional salt and water balance models, monitoring and evaluation of irrigation system performance in saline irrigated command using remote sensing and GIS and developing technologies for skimming and recharging fresh water in saline groundwater regions are some of the major issues being addressed in the Division of Irrigation and Drainage. Development of high yielding salt and waterlogging tolerant genotypes of rice, wheat and mustard following conventional and modern breeding and assimilating physiological approaches are the major concerns in the Division of Crop Improvement. The Division of Technology Evaluation and Transfer identifies constraints in the adoption of soil reclamation technologies besides evaluating their impact on rural development.

The All India Coordinated Research Project (AICRP) on Management of Salt Affected Soils and Use of Saline Water in Agriculture established in 1972, started with 5 centers. It
is currently being operated at 8 centers covering arid, semi arid, irrigated, rain fed and coastal ecologies. The mandated tasks include development of technologies to solve local problems and to participate in developing regional and national guidelines on management of salt affected soils and use of saline water in agriculture.
THE CSSRI made a clear dent on Indian agricultural scene as is evident from the rapid spread of its technologies and wide spread adoption of alkali soil reclamation package. However, unfinished agenda in the form of vast areas still lying barren in many parts of India, increasing spread of waterlogging and salinity due to increase in irrigated area, increasing threat of deterioration in water quality, sustaining the productivity in post-reclamation phase, increasing the fuel wood production from degraded lands, the urgent need to conserve gene pools of useful crop plants, increase the tolerance of crop plants by molecular biological approaches and the need to develop reliable resource inventories on salty soils and waters still remain to be addressed. The CSSRI will stride forward with renewed vigour to take up these challenges for the betterment of the farming community and other stakeholders.

**Vision**

Productive utilization of salt affected soils and poor quality water resources in varying agro-ecological situations.

**Mission**

Generating new knowledge and understanding of the processes of reclamation and developing technologies for improving and sustaining productivity of salty land and waters.

**Focus**

To realize the vision and mission of CSSRI, it will concentrate on the following key areas with strength drawn from the past research and extension experiences and providing due consideration to the emerging challenges that are being faced by present day agriculture.

- Resource inventories on waterlogged, salt affected soils and poor quality waters for land use planning
- Focus on issues of water quality including recycling of sewage and industrial effluents for agriculture
• Diversification strategies in salt-affected arid lands underlain with poor quality ground water resource
• Sustaining productivity in post-reclamation phase in relation to soil and water quality vis-à-vis organic matter dynamics and carbon sequestration
• Breeding for abiotic stresses including soils and waters contaminated with heavy metals
• Alternate management strategies for waterlogged saline lands, which may include drainage, aquaculture and bio-drainage
• Multiple use of poor quality water for multi-enterprise agriculture to increase water productivity and farmers’ income
• Bio-saline agro forestry for fuel wood, forage and energy production
• Ground water recharge as related to ground water quality and its management
• Strategies to ensure double cropping in coastal saline soils
• Reclamation and management of salt affected Vertisols
• Reclamation and management of alkali soils of central and eastern Gangetic plains
• Technology transfer, impact assessment and human resource development in the emerging areas
• Impact of climate change on soil reclamation and crop yield
Harnessing Science

It will be the endeavor of Central Soil Salinity Research Institute to address the problems of soil salinity and water quality through synergies of frontier science like remote sensing and GIS (Geographical Information System), management of natural resources including adoption of conservation agriculture, crop diversification, energy management and utilization of agricultural waste. Thrust will be on tapping the potential genetic resources for varietal improvement through molecular biology. Researches would be linked to post-harvest, value addition and supply chains being important to increase net profit to the farmers. Increasing bio-risk in agriculture due to climate change and owing to trans-boundary insect-pests and diseases especially in coastal region would be addressed. Thrust will also be on transfer of technologies and human resource development through education of scientific, technical and administrative personnel so as to make research programmes more need based and effective.

Synergies of frontier science

Frontier scientific tools of geospatial technology such as remote sensing and GIS, together with the new sensor and image processing technology with soft computing techniques will be applied in the mapping and monitoring of salt affected soils at district and regional levels. Integration of these technologies for development of geospatial database with modelling will help in building decision support system (DSS) for providing alternate solutions under different scenarios of saline environments for optimum utilization of salt affected soils and poor quality waters.

Management of natural resources

Management of soils and water is the most important challenge to enhance agricultural production and productivity in salt affected environments. Dynamic changes in the extent and magnitude of salinity level of both soil and water need to be managed efficiently for sustaining crop productivity. These changes
can be managed efficiently through various land shaping techniques, which in turn can be utilized for multiple cropping.

Another important area is integrated nutrient management using local resources, vermicompost, use of bio-fertilizer, etc. for maintenance of soil health, better management of salt affected soils considering poor economic status of farming communities.

Low agricultural productivity is a major constraint to sustain and uplift the agriculture-dependent livelihoods of millions. Despite of saline alkali ground water, arid and semi-arid regions are endowed with good climatic conditions and limited freshwater resources, which in conjunctive mode could increase agricultural productivity substantially and help to improve the livelihoods of people dependent on agriculture.

At present, agriculture is a major user (83%) of good quality water resources. The current demand of first priority users (domestic use, energy, industry) is around 11% of the total water supply of 62.9 million ha-m and is likely to double by 2030. Even under the current scenario, paradoxical situations of declining and rising groundwater table have developed in most states. The disposal and reuse of solid wastes and sewage water etc., is of great concern due to their effects on soil and ground water quality and on human and animal health. We will also have to cope up with greater volumes of effluent in not too distant future. With increasing competition for good quality water from other sectors of economy, agriculture will have to depend on marginal quality waters for irrigation. Problems of water quality will have to be seen in the context of a river basin, where water quality deteriorates towards tail end. The existing temporal and spatial variations in water quantity and quality will get further accentuated and coping strategies including guidelines and standards for reuse/sequential use will need a fresh look. Optimum pumping strategies, diversification of crops and recharge technologies need to be developed for areas experiencing declining groundwater tables. In coastal areas also, as irrigation water is highly scarce, harvesting of rainwater, mulching etc. have to be practiced. Besides, water saving technologies such as drip irrigation, pitcher and furrow irrigation would have to be popularized.

**Conservation agriculture**

In the post-reclamation phase, the focus has shifted to precision farming and the adoption of low cost water and energy saving technologies for enhancing rice-wheat productivity in reclaimed sodic soils and improving carbon sequestration. Development of resource conservation technologies will aid in increasing the potentiality of yield and
also conserve energy and cost. Technologies like zero tillage in wheat, direct seeding in rice, exploiting residual soil moisture after kharif by introducing paira cropping, use of bio-degradable environmentally safe weedicides, practicing minimum tillage and diversification of crops have to be increasingly adopted.

**Potential of genetic resource enhancement**

There is a strong need to develop varieties having resilience to multiple stress situations so as to provide sustenance to food production. Many of the donors of salt tolerance mechanisms in established varieties have come from local land races. The coastal region of India is rich in rice diversity particularly the land races tolerant to salinity. Many of these traditional rice varieties have great potential to be used for future varietal improvement programme. Besides, the coastal region of Sundarbans is one among the biodiversity hotspots areas of the world and many of the plant species can be utilized as agro-forestry crops. The strategy will include assembling, characterizing, documenting, conserving and utilizing salt tolerant crop genetic resources, and also elucidation of mechanisms of plant adaptation to saline environment.

**Varietal improvement through molecular biology**

Cutting edge tools like application of molecular biological techniques have great potential to address the future challenges that are likely to emerge in the management of salt affected environments. The tolerance of the breeding lines in most cases is not as high as that of the traditional donors, reflecting the difficulty in obtaining high tolerance while avoiding the negative characters of the donor land races (Gregorio et al., 2002). This complexity, together with the multiple traits involved and the diversity of target environments slowed the progress in the development of new varieties. Recent successes through incorporation of salt tolerant gene into high yielding rice varieties have been quite encouraging and have substantial positive implications particularly for coastal areas (Ismail et al., 2008, Bonilla et al., 2002, Ismail et al., 2007). Developments in molecular biology, biotechnology, nanotechnology, information technology and geo-spatial technology are expected to provide significant new opportunities for productivity enhancement (ICAR 2011). Biotechnology can be useful in enhancing yield potential and also improving the product quality. Since most of the crops lack suitable varieties
for coastal areas, application of cutting age technologies for varietal improvement has great potentiality.

**Agricultural diversification**

Diversification of agriculture through agro-forestry is an important proponent for resource utilization, enhancing farm income and livelihood security of farmers in the traditionally mono-cropped areas of the country. Some of the key strategies for diversification will be appropriate integrated cropping system models using pisciculture and animal husbandry on mono-cropped areas for increasing productivity of land and to reduce the risk factor in agriculture. With more than 85% of the cultivable land in coastal zone being mono-cropped with *kharif* rice, there is a potentiality of growing low water requiring commercially viable vegetable crops in *rabi/ summer* season having good market demand.

**Post-harvest, value addition and supply chains**

Enabling and functioning of an efficient marketing system would help increase the area under high value crops and may ensure remunerative prices to the primary producers. With several innovations and alternative marketing systems in place, agricultural marketing is now more liberated and private players are allowed to participate actively. The ongoing liberalization process and entry of private players in agricultural marketing have made this issue an important component in overall agricultural development of a region. A strong chain for supply of inputs and sale of produce needs to be developed through multi stakeholder partnership.

**Management of energy and agricultural waste**

Energy requirement for agriculture is growing rapidly due to mechanization and agricultural intensification. To meet the future energy requirement as well as to reduce the dependence on conventional (non-renewable) energy resources, there is a need to explore the alternative (un-conventional or renewable) energy sources from biological or natural resources. Bio-fuel production and use from potential crops needs to be explored. The alternative energy sources like wind power, solar, etc. can be harnessed.
for agricultural purposes particularly in coastal regions where even tidal energy could be utilized to produce energy.

**Climate change adaptation of crops**

Currently the most discussed subject is climate change. It would have a significant role in development and management of salt affected soils and more so in the use of poor quality waters. Researches on effect of climate change on rice, wheat and other crops cultivated in sodic soils will help in the development of mitigation strategies. Coastal region of India is likely to be one of the worst sufferers on account of changing climatic scenario. Strategies need to be evolved for suitable management of resources, development of crop varieties tolerant to cold wave and terminal heat etc., and cultural practices for adaptation to climate change and sea level rise.

**Risk management**

Global village concept has resulted in closer interactions between the global communities. Besides, coastal regions of India share boundaries with many countries and act as an entry point for several agri-commodities, which is often associated with increased risk of transmission of insect, pest, weeds and diseases having direct or indirect bearing on agriculture. Bio-risk as well as risks in general is likely to increase exponentially with climate change and add to the production cost. Although bio-risk is not directly related to the institute activities, efforts would be made to minimize the other risks by developing effective and integrated risk-and-disaster management production systems. Risk intelligent systems (such as early warning systems, heavy rainfall, climatic disaster, drought indicators, migratory movement of bio-risk agents, etc.) would be developed for taking informed decisions.

**Education and human resource development**

Education and human resource development is crucial to upgrade skills and knowledge of the scientific as well as other staff members to make research programmes more need based and effective. National and international collaboration would be ensured to keep abreast with the state-of –the- art knowledge across the globe. Knowledge empowerment will be given special priority to increase the competence level, competitiveness and the efficiency of the human resource of the institution.
Technology transfer system

Assessment of technology and their refinement for higher income and improvement of productivity through location-specific multi-disciplinary technological interventions with the active involvement of scientists, farmers, extension workers etc. would be carried out in an intensive manner. Management efforts would be made to dovetail the activities with ongoing National Missions addressing the issues of water and land, horticulture and climate change at district/ block levels.
SPECIFIC strategies (Annexure 1) will be adopted for rehabilitation of salt affected lands and sustainable use of poor quality waters for irrigation. Focussed attention is warranted in certain spheres of research in the next two decades. Some of them being: development of alkali soil reclamation technology for areas underlain by shallow water table, brackish water or areas with limited access to irrigation water, integration of subsurface and bio-drainage for saline waterlogged soils, subsurface drainage for heavy soils, novel methods of utilizing saline, alkali and toxic waters including the waste waters from urban areas, diversification of existing cropping patterns on reclaimed and semi-reclaimed soils through farming system approach, improving salt tolerance of crops by marker assisted selection, alternate uses of marginal soils for growing agro-forestry, bio-saline agriculture and energy plantations, resource conservation technologies in unreclaimed/semi-reclaimed/reclaimed soils, value addition in naturally growing halophytes and new farmer centric innovative approaches for increasing the pace of technology transfer to marginal production environments. Economic assessment of technology and research prioritisation will increasingly use indices like equity and sustainability. Human resource development will be reoriented to meet the increasingly sophisticated needs in the emerging situations. Broadly, these strategies will encompass

- Management of natural resources for improving efficiency
  - Developing a dependable data base on 1:50,000 scale for suitable land use planning
  - Integrated nutrient management for improved soil health and environmental protection
  - focused attention on conservation agriculture including direct seeded rice
  - Management of coastal salt affected soils, acid sulphate soils
  - Addressing micronutrient deficiencies
  - Develop and promote suitable water conservation and harvesting measures for enhanced water productivity in salt affected ecosystems

- Stress management through improved genetic plant adaptation
  - Assembling, characterizing, documenting and utilizing plant genetic resources with relatively higher tolerance to salinity and related stresses
– Development of varieties having multiple tolerances to various biotic and abiotic stresses
– Development of varieties having high efficiencies in terms of inputs use
– Screening tree species for agro-forestry, domestication and value addition of natural species
– Development technologies for improved agro-forestry systems
– Conserving, characterizing, documenting and utilizing mangrove resources

• Strategies for climate change mitigation
– Development of crop varieties and cultural practices for adaptation to climate change and sea level rise as a result of global warming
– Forewarning and forecasting models with different approaches of ICT (Information Communication Technology)
– Contingency crop plans for emergent situations following cyclones, flood and similar other situations

• Farming system model for livelihood
– Site specific integrated farming system approach with pisciculture, animal husbandry, horticulture, etc. for enhancing productivity and to reduce the risks involved in mono-cropping
– Aquaculture-based system for coastal agriculture

• Transfer of technology, impact assessment, value addition and market linkages
– Extension of new technologies, human resource development, gender studies for empowering women farmers/agriculture workers
– The post harvest management and value addition infrastructure and marketing linkages
LIVELIHOOD of millions of people dwelling in salt affected areas depends on locally available natural resources. Appropriate management of natural resources for agricultural purposes is thus, extremely vital to improve income and ensure food security of the local populace. Sustained research efforts are needed to arrive at practical cost-effective solutions to solve the existing problems and to address the upcoming challenges that are likely to affect the holistic development of salt affected soils/water. For example, climate change, which is no longer a distant reality now, would adversely affect the land and water resources in general but still more severely in coastal areas. Researches on adaptations in agriculture to the changing environment and scientific mitigation strategies would be needed to safeguard livelihoods of millions and for maintaining overall ecological balance. Besides, CSSRI will focus on developing innovative and creative technologies for the emerging issues of poor quality waters, problems of heavy metals and for biosaline agriculture. It would also document their impact on soil-water-plant-human continuum. The institute will sensitize and facilitate policy interventions to upstream, upscale and speed up the rate of reclamation through viable technologies.

Strengthening the research institute adequately with infrastructure, manpower and financial provisions would certainly facilitate shouldering the greater responsibility in times to come and to take forward the sustainable agricultural development in salt affected areas. Although the management of salt affected soil do catch the immediate attention of all concerned as it helps to augment productivity, the various agro-ecological factors demand that it should be mandatory to have a holistic approach and special attention to their interaction matrix to ensure lasting stability of the ecosystem and betterment of farming community. It will be the endeavour of CSSRI to march forward towards this vision.


### Annexure 1: Strategic Framework

<table>
<thead>
<tr>
<th>Goal</th>
<th>Approach</th>
<th>Performance measure</th>
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</table>
| Resource inventory of salt affected soils | • Generation of credible database on distribution and extent of different types of soils and the degradation status using latest technology of remote sensing and GIS  
• Generation of credible database on poor quality waters and waste waters using latest technology of remote sensing and GIS  
• Genesis of salt affected soils and poor quality waters | Creation of databank Publications                                                                                                           |
| Management of salt affected soils by adopting systems approach | • Strategies for arresting land degradation through suitable soil and water management, adopting nano technology, mulching with organic farm and urban wastes and other low cost materials  
• Methodology for increasing *in-situ* availability of calcium for sustainable sodic soil reclamation  
• Development of appropriate resource conservation technology for salt affected soils with higher productivity and carbon sequestration  
• Location specific low cost integrated plant nutrient management using micronutrients, local organic wastes and bio-fertilizers  
• Development of techniques for reducing drainage congestion at farmers’ field  
• Amelioration of coastal problem soils like, acid sulphate soils, sodic soils in coastal areas with suitable amendments  
• Management of waterlogged soils  
• Floating agriculture in highly waterlogged areas specific of coastal areas and in wetlands  
• Cultivation of sea weeds for coastal land management | Area reclaimed  
Productivity increased  
New/ improved technologies developed |
<table>
<thead>
<tr>
<th>Management of poor quality waters</th>
<th>New/improved technology developed</th>
<th>Productivity increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Developing improved techniques for harvesting excess rainwater for creation of irrigation resources at farmer’s fields</td>
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<tr>
<td>• Efficient utilization/re-use/multiple use of available water</td>
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<tr>
<td>• Horizontal, vertical and bio-drainage systems for waterlogged saline soils in particular for salt affected Vertisols; socio-economic and transfer of technology mechanism</td>
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<tr>
<td>• Remote sensing and GIS based diagnosis, prognosis, mapping and modelling systems for evaluation of irrigation and drainage projects</td>
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<tr>
<td>• Benchmarking of tube well water quality, regional plans for holistic management of land and water resources including regional salt and water balances for northwest states</td>
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<tr>
<td>• Saline aquaculture and drip-horticultural crop systems for waterlogged saline lands</td>
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<td></td>
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<tr>
<td>• Develop techniques for reducing salinity build-up in soil and water during dry months</td>
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<tr>
<td>• Exploration of groundwater potentialities and scope of recharging using excess rain water to augment groundwater and improve its quality</td>
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<tr>
<td>• Development of advance techniques for use of poor quality water including sea water in agriculture</td>
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<tr>
<td>• Developing eco-friendly low cost techniques (like growing of salt tolerant plants/mangroves) for protecting embankments from thrust of waves from the sea/river</td>
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### Crop Improvement

- Assessing and utilizing plant genetic resources with higher tolerance to salinity and related stresses
- Use of cutting edge technologies for development of crop varieties for different stress conditions (salinity, submergence, multiple stresses etc.)
- Development of varieties having higher efficiencies in terms of inputs use
- To act as national repository of locally adapted cultivars tolerant to salinity/sodicity and waterlogging conditions with a capability to help the farmers of areas, hit by severe natural disasters like cyclones in coastal areas, to revive crop production by providing nucleus seed of salt-tolerant and locally-adapted crop varieties

<table>
<thead>
<tr>
<th>Varieties developed/identified</th>
</tr>
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| Local landraces used for varietals development research programme
| Extent of yield improved |

### Alternate Land Use

- Evolving appropriate alternate land use options for small and marginal land holdings to enhance water productivity and livelihood under saline and sodic ground water irrigation
- Feasibility of growing diversified crops including high value and non-conventional crops like, spices, aromatic plants, fruit crops, etc. instead of monocropping with rice
- Multiple cropping

| Better use of available land and water resources for increased production |

### Farming system model

- Evolving improved/alternate and integrated farming system models for salty soil and waters
- To identify suitable fish species under inland saline water

| Enhanced income from farming system model |
| Vision 2030 |
|-----------------|-----------------|-----------------|
| **Aquaculture for livelihood in coastal areas** | **Ecology and climate change adaptations** | **Higher income and better livelihood of farmers through utilization of available water resources** |
| - Evolving low input low cost aquaculture farming system especially for small land holders | - Developing comprehensive technology packages for climate change adaptations | - Making available guidelines for sustainable agriculture |
| - Evolving efficient models of crop-fish cultivation for large numbers of small and marginal farmers in the coastal areas | - Evolve suitable varieties of crops, particularly rice, to suit the changing cropping pattern and soil-water deteriorations under changing climate | |
| - Effective use of brackish water for profitable aquaculture at small farmers’ level | - Evolve low cost integrated farming of crop-fish-animal husbandry suitable for marginal farmers for adaptations under changing climate | |
| - Location specific potential for low cost feed supplements for fish to be developed using local resources | - Restoration and conservation of mangroves in coastal areas | |
| - Composite culture, shrimp/prawn culture, mussel and crab etc. | - Draw suitable farming practices under contingent events of cyclones, saline water flooding, tsunami and other natural calamities in coastal areas | |
| - Introduction of non-conventional aquaculture like ornamental fish culture, mussel culture, pearl culture, etc. for small farmers | | |

Higher income and better livelihood of farmers through utilization of available water resources

Improved productivity of water bodies

Making available guidelines for sustainable agriculture
### Transfer of Technology, Impact Assessment, Value Addition and Market Linkages

- **Agro-centres to be developed for resource poor farmers in different salt affected eco-regions**
- **Producers participatory approach in marketing to be developed to help the farmers of remote areas to stand against exploitation through utilisation of market intelligence**
- **Communication facilities to be developed for over-all development and technology transfer**
- **Transfer of alkali soil reclamation technology through PPP model**

Frontline demonstrations carried out
Exhibitions and training programmes organized
Number of technologies popularized
Evolving possible measures for value addition of crops and establishment of market linkages towards higher farm income

### Human Resource Development

- **Modernize training systems by strengthening infrastructural facilities and gender mainstreaming**
- **Capacity building through trainings at national and international levels to address emerging challenges in the field of management of salt affected soils and use of poor quality waters**
- **Training of the rural youth regarding management of salt affected soils and use of poor quality waters**

Improved technology evaluation and transfer efficiency
Qualified manpower in managing salt affected soils and use of poor quality waters developed