INTERNATIONAL CONFERENCE

On

Soil and Water Resources Management for Climate Smart Agriculture, Global Food and Livelihood Security

November 05th-09th, 2019
NASC Complex, New Delhi, India

SOUVENIR




A Joint International Conference of

SOIL CONSERVATION SOCIETY OF INDIA

ISCO International Soil Conservation Organization

WASWAC

Soil Conservation Society of India (SCSI)
World Association of Soil and Water Conservation (WASWAC)
International Soil Conservation Organization (ISCO)

Organized by

Soil Conservation Society of India, New Delhi, India

Sponsored by

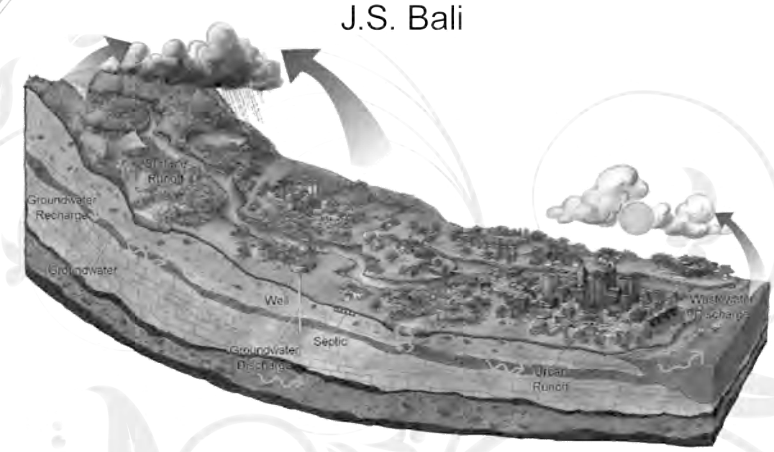
ICAR NABARD IRRI SERB Indian Council of Social Science Research इसरो isro CSIR INDIA

Supported by

International Union of Soil Sciences   ESSC European Society for Soil Conservation

Pledge

J.S. Bali



I pledge to conserve Soil,
that sustains me.
I pledge to conserve Water,
that is vital for life.
I care for Plants and Animals and the Wildlife,
which sustain me.
I pledge to work for adaptation to,
and mitigation of Global Warming.
I pledge to remain devoted,
to the management of all Natural Resources,
With harmony between Ecology and Economics.

J.S. Bali

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Editors

- Suraj Bhan
- Sanjay Arora

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WASWAC
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Organized by
Soil Conservation Society of India,
National Societies Block A/G-4,
National Agricultural Science Centre Complex, Pusa, New Delhi 110 012
Tel.: 011-25848244; *Telefax:* 25848244;
Email: soilcsi@gmail.com, *Website:* www.scsi.org.in

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डि. प्रशांत कुमार रेड्डी, भा.प्रशा.से.
D. Prasanth Kumar Reddy, IAS

भारत के उप-राष्ट्रपति के निजी सचिव
PRIVATE SECRETARY
TO THE VICE-PRESIDENT OF INDIA
नई दिल्ली/NEW DELHI - 110011
TEL.: 23016344 / 23016422 FAX : 23018124

Shri. Venkaiah Naidu
Hon'ble Vice-President of India

Message

The Hon'ble Vice President of India is happy to know that the Soil Conservation Society of India (SCSI) is organizing its 4th International Conference on "Soil and Water Resources Management for Climate Smart Agriculture, Global Food and Livelihood Security" from November 5 – 9, 2019 in New Delhi.

The Hon'ble Vice President extends his greetings and congratulations to the organizers and the participants and wishes the event all success.

(D. Prasanth Kumar Reddy)

New Delhi
16th September, 2019.

नरेन्द्र सिंह तोमर
NARENDRA SINGH TOMAR

सत्यमेव जयते

कृषि एवं किसान कल्याण,
ग्रामीण विकास तथा पंचायती राज मंत्री
भारत सरकार
कृषि भवन, नई दिल्ली

MINISTER OF AGRICULTURE & FARMERS' WELFARE,
RURAL DEVELOPMENT AND PANCHAYATI RAJ
GOVERNMENT OF INDIA
KRISHI BHAWAN, NEW DELHI

Message

The agriculture and allied sectors continue to be the largest source of livelihood security for millions of households across the world. The demand for food, fruit, feed, fiber and fuel is on rise that has led to intensification of agriculture. Also, there is increased diversion of natural resources such as land and water for non-agricultural use due to rising global population, urbanization and industrialization. There is urgent need for innovations to improve efficiency, equity and environment with simultaneous enhancements in farm productivity and profitability.

In the Indian context, the Conference would provide solutions in achieving our goal of sustaining agricultural growth at 4 per cent per annum and maintaining soil and water resources. I am happy to note that the themes of the Conference cover the most pertinent issues in the context of overall agricultural development. I hope the deliberations during the Conference will result in a road map in support of holistic development agenda, and bring out recommendations for future approaches and innovative techniques for applications in the entire value chain with farmers and market occupying the central place.

I congratulate Soil Conservation Society of India for taking the responsibility and for their efforts to jointly organize International Conference on Soil and Water Resources Management for Climate Smart Agriculture and Global Food and Livelihood Security with World Association of Soil and Water Conservation and International Soil Conservation Organization supported by Indian Council of Agricultural Research (ICAR), National Biodiversity Authority and other national and international organizations. I wish the event all success.

(Narendra Singh Tomar)

Office: 'G' Wing, Ground Floor, Krishi Bhawan, New Delhi- 110001, Tel.: 011-23782373, 23782327 Fax: 011-23385876
Resi.: 3 Krishna Menon Marg, New Delhi-110001, Ph.: 011-23794697/98, Fax: 011-23794696

गजेन्द्र सिंह शेखावत
Gajendra Singh Shekhawat

सत्यमेव जयते

जल शक्ति मंत्री
भारत सरकार
Minister for Jal Shakti
Government of India

01 OCT 2019

MESSAGE

There is no doubt that modern agriculture has delivered increases in food production that were unimaginable only a half a century ago. But many parts of the world, these gains have resulted in enormous consequences for the natural resource base and ecosystems that we all depend on. Groundwater reserves in many parts of Asia, and particularly parts of India, are running out; soils have become seriously degraded; rivers have become polluted and in some cases have completely run dry.

With the world population expected to reach 9 billion by 2050, these problems are likely to become increasingly severe.

I am very pleased to support the efforts of the soil Conservation Society of India in jointly organizing the 4th International Conference on **Soil and Water Resources Management for Climate Smart Agriculture and Global Food and Livelihood Security** during November 5-9, 2019 at New Delhi.

I hope that the deliberations and discussions during the conference will culminate in meaningful strategies for the sustainable use our precious natural resources to alleviate hunger, improve the quality of life, and safeguard the environment.

I extend my best wishes to the organizers and participants for a successful conference.

(GAJENDRA SINGH SHEKHAWAT)

जल शक्ति अभियान
संचय जल, बेहतर कल

Office : 210, Shram Shakti Bhawan, Rafi Marg, New Delhi-110 001
Tel: No. (011) 23711780, 23714663, 23714200, Fax : (011) 23710804
E-mail : minister-mowr@nic.in

परशोत्तम रूपाला
PARSHOTTAM RUPALA

सत्यमेव जयते

राज्य मंत्री
कृषि एवं किसान कल्याण
भारत सरकार
Minister of State For
Agriculture & Farmers Welfare
Government of India

D.O. No. 467 ......MOS(A&FW)/VIP/2019-20/

September 19, 2019

Message

I am happy to know that Soil Conservation Society of India is hosting an International Conference on "Soil and Water Resources Management for Climate Smart Agriculture and Global Food and Livelihood Security" from 5-9 November, 2019 at New Delhi. It gives me immense pleasure to know that a Souvenir is also being published on this occasion.

As I understand, this conference will be attended by National and International scientists, policy makers, researches extension field functionaries, farmers, executives, NGO's and students. I hope the discussion during the conference will put forward some innovative approaches for climate smart agriculture vis-a-vis feasible techniques for conservation of soil and water resources.

It is my pleasure to wish the organizers and participants for the success of this conference and wish the event a grand success.

(Parshottam Rupala)

Delhi Office : Room No. 322, 'A' Wing, Krishi Bhawan, Dr. Rajendra Prasad Road, New Delhi-110 001
Tel. : +91-11-23383975/76 **Fax** : +91-11-23383971, **E-mail** : mosrupala@gmail.com
Gujarat Office : Plot No. 219, Sector-20, Gandhinagar-382 020 **Tele.** : 079-23260013

कैलाश चौधरी
KAILASH CHOUDHARY

कृषि एवं किसान कल्याण
राज्य मंत्री
भारत सरकार
MINISTER OF STATE FOR AGRICULTURE & FARMERS WELFARE
GOVERNMENT OF INDIA

सत्यमेव जयते

Message

I am indeed happy to learn that the Soil Conservation Society of India in jointly organizing the 4th International Conference on **Soil and Water Resources Management for Climate Smart Agriculture and Global Food and Livelihood Security** during November 5-9, 2019 at New Delhi and the Indian Council of Agricultural Research (ICAR) as a sponsor.

Soil and water management in the changing climate is a pre-requisite for sustainable agriculture production. The social, economic, environmental and political impacts are significant to achieve sustained agricultural growth. Natural resources are critically important components of life support system, the efficient conservation and management of which are vital for achieving food and livelihood security with economic growth and rural development. The degradation of our natural resources, soil and water has become a matter of serious concern for the farmers, researchers, academicians, scientists and policy makers, as these in turn affect issues like upliftment of rural people, food security and livelihood.

I hope the International Conference will focus on the protect, conserve and develop the natural resources and use them sustainably basis to alleviate poverty, hunger, enhance livelihood security, environmental stability and improve the quality of life.

I wish the event grand success.

(Kailash Choudhary)

Dated 18.09.2019
New Delhi

Office : 199Q, Krishi Bhawan, New Delhi-110001, Tel. : +91-11-23782343, 23388165 (KB), Fax : 23074190

M S Swaminathan Research Foundation
Third Cross Street, Taramani Institutional Area
Chennai - 600 113

Prof (Dr) M S Swaminathan
Chief Patron, SCSI

Message

Long ago Aristotle said that soil is a stomach of the plant. Soil conservation and sustainable use holds the key to successful agriculture and sustainable food security. I am therefore very happy that the Soil Conservation Society of India is organizing an International Conference to develop a strategy for soil health care. I wish the Conference great success.

M S Swaminathan
Founder Chairman, MSSRF

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Tel: +91 44 2254 2790 / 2254 1229 / 2254 1698; Fax: +91 44 2254 1319
Email: founder@mssrf.res.in
Twitter: @msswaminathan

सत्यमेव जयते

त्रिलोचन महापात्र, पीएच.डी.
एफ एन ए, एफ एन ए एस सी, एफ एन ए ए एस
सचिव एवं महानिदेशक

TRILOCHAN MOHAPATRA, Ph.D.
FNA, FNASc, FNAAS
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE AND FARMERS WELFARE
KRISHI BHAVAN, NEW DELHI 100 001
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

Message

I am pleased to know that a joint International Conference on **Soil and Water Resources Management for Climate Smart Agriculture and Global Food and Livelihood Security** is being organized jointly by the Soil Conservation Society of India, World Association of Soil and Water Conservation and International Soil Conservation Organization from 5-9 November 2019 at New Delhi, India. The conference supported by Indian Council of Agricultural Research (ICAR), National Biodiversity Authority and other organizations is very timely and commendable.

Natural resources are critically important components of life support system, the efficient conservation and management of which are vital for achieving food and livelihood security with economic growth and rural development. With increasing demand from land, mainly due to increasing population, life style changes, urbanization, industrialization and other non-farm uses, diversion is taking place not only from wastelands but also from agriculturally and ecologically significant areas such as forest and pasture lands. The soil and water conservation technologies play a major role in mitigating the impact of climate change on yield of various crops. The degradation of our natural resources, soil and water has become a matter of serious concern for the farmers, researchers, academicians, scientists and policy makers, as these in turn affect issues like upliftment of rural people, food security and livelihood.

It is expected that the deliberations during the Conference will culminate in developing strategies and an action-oriented road map to promote conservation of natural resources and strategies for combating the adverse effect of climate change.

I convey my best wishes for the success of the International Conference.

(T. MOHAPATRA)

Dated the 4th October, 2019
New Delhi

Dr Peter Carberry
Director General, ICRISAT
Email: p.carberry@cgiar.org
Mobile: +91 70 32122284; Phone: +91 40 30713221
Fax: +91 40 30713074; Skype: peter.stanley.carberry
International Crops Research Institute for the Semi-Arid Tropics
ICRISAT - www.icrisat.org
Address: Patancheru, Hyderabad, Telangana - 502324, India

Message

Soil and water conservation technologies have been one of the driving forces for increasing agricultural productivity, and such impacts are particularly evident in India. Choice of technologies and their adoption were targeted to reduce soil erosion, rehabilitate degraded lands, enhance groundwater recharge, enhance soil moisture retention, all of which resulted in productivity enhancement and crop intensification.

ICRISAT and consortia partners have developed, tested and implemented a number of soil and water conservation technologies specific to different rainfall and agro-ecological regions. These technologies are helpful in terms of enhancing soil moisture availability, enhancing groundwater recharge and crop intensification in upstream areas while controlling soil erosion and flooding on downstream locations. This knowledge was scaled up through various research and government-funded initiatives in semi-arid regions by developing sites of learning. ICRISAT and its partners have contributed towards understanding impact of soil and water conservation measures at different scales (field, watershed and national scale) which has helped development practitioners and policy makers to formulate appropriate policy guidelines on soil and water conservation measures.

Soil and water conservation technologies need to be strengthened to mitigate climate change and to build system resilience. The interface among academia, researchers, Government departments, policy makers, farmers, industry and other stakeholders prepares the road maps for developing farmer-friendly, innovative and low cost soil and water conservation technologies.

I applaud the joint efforts of the Soil Conservation Society of India, WASWAC and ISCO to organize the International Conference on **Soil and Water Resources Management for Climate Smart Agriculture and Global Food and Livelihood Security**. The conference will delve into the links between sustainable agriculture and management of natural resources to create sustainable, resilient and nutritious food systems for the present and future.

I extend my good wishes to the delegates and the organizing team.

Peter Carberry

Dr. Matthew Morell
Director General
International Rice Research Institute

Message

On behalf of the International Rice Research Institute, I would like to congratulate the Soil Conservation Society of India for hosting the Soil and Water Resources Management for Climate Smart Agriculture, Global Food and Livelihood Security international conference in India.

This conference highlights the urgency of the challenges our world is facing, and underscores the importance of collaboration and collective action. I am particularly pleased to see the joint efforts by the Soil Conservation Society of India, the World Association of Soil and Water Conservation, and the International Soil Conservation Organization, with support from the Indian Council of Agricultural Research, National Biodiversity Authority, and other key organizations in developing a robust programme for this conference.

Resource-efficient, location-specific, and scalable, water, soil, nutrient, and pest management solutions define the cornerstone of sustainable agriculture, against the backdrop of a sensitive food-water-energy nexus.

The deliberations from this conference, emanating from its rich confluence of experts, scientists, and policy-level influencers from across the globe, will be an important step forward in achieving the Sustainable Development Goals, and for finding solutions to safeguard and sustain our natural resources for current and future generations.

I hope your discussions and scientific reflections will lead us into a greater understanding of what can be done, and what we can do together through a shared vision and a common goal.

I convey my best wishes for the success of this international conference.

Sincerely,

Matthew Morell

Alok K. Sikka
IWMI Representative-India,
IWMI New Delhi Office, CG Block C, NASC
Complex, Pusa,New Delhi 110012, India
Ex DDG (NRM), ICAR

Message

Management of land and water resources is critical for realizing the objective of meeting food and water security of the growing population. There is global consensus that current climate is changing and it's for real. Agriculture is one sector of the economy that is exposed directly and considerably affected by climate change and climate variability. The erratic rainfall patterns, trends of increase in atmospheric temperatures, occurrence of droughts, floods etc. have all sounded the alarm bells towards effective adaptation and management of the natural resources. Sustainability of land and water resources is now challenged under changing climate scenario.

Rural communities throughout India are struggling with the realities of increasing climatic variability and climate change, together with declining farm productivity and rising cost of cultivation associated with depleting and degrading natural resources. India is especially vulnerable to climate change given its dense population dependence on agriculture, excessive pressure on natural resources and poor coping capabilities. The anticipated impact of climate change is likely to lead to increased stress on already scarce land and water resources. Resilient agriculture therefore requires a major shift in the way land and water are managed to ensure that these resources are used more efficiently.

Recently launched Global Commission on Adaptation report has clearly highlighted the multiple benefits of adaptation and identified investments in dryland agriculture and water management amongst the five potential areas of adaptation. Land and water management is a key element of building resilience for climate change adaptation and achieving Sustainable Development Goals (SDGs). Enhancing natural and social capital in rural areas through a mix of land and water management solutions, rooted in the principles of ecosystem-based approach deserves focus to build resilience for climate smart agriculture.

Collaborative and concerted efforts of the organizers of this International Conference on "**Soil and Water Resources Management for Climate Smart Agriculture, Global Food and Livelihood Security**" are the timely steps in right direction to provide a platform where users, experts and policy makers from different countries are intended to deliberate on different emerging issues and challenges in the field of natural resources management. I am sure that thought-provoking discussions/deliberations will be held on land and water management, restoration of degraded lands, drought, climate change, renewable energy, women empowerment, gender equality, water scarcity and various other issues covering different themes in this conference. I congratulate the organizers for conducting this event to address global concerns and I wish this conference a grand success.

(**Alok K. Sikka**)

International Union of Soil Sciences

Prof. Rattan Lal
Past President, IUSS

10th September, 2019

Message

I commend the Organizing Committee for planning, conceptualizing, and bringing to fruition the International Conference on a timely theme of global significance. Sustainable management of soil and water for climate – smart agriculture and global food and livelihood security is an urgent issue. I also extend a warm welcome to all participants, and wish you productive and professionally rewarding deliberations.

Accelerated soil erosion has plagued agricultural land ever since the onset of settled agriculture 10 to 12 millennia ago. The problem of accelerated erosion (caused by water, wind, gravity, tillage, stream flow, and coastal waves) is exacerbated by the predominantly extractive farming systems widely practiced by resource-poor farmers and small landholders, and inappropriate landuse and management for quick economic returns by large and commercial farms.

Notable among the extractive farming practices are removal and/or in-field burning of crop residues, uncontrolled grazing, little or unbalanced use of chemical fertilizers (i.e., more nitrogen and less phosphorus, potassium, and micro-nutrients), little or no use of compost or green manure, continuous cropping with grain-based rotations without incorporation of legumes as cover crops or forages scalping of top soil for brick making, and flood-based irrigation. Examples of inappropriate practices by large-scale commercial farms are excessive plowing, monocropping, indiscriminate use of agricultural chemicals, heavy machinery traffic, among others. Prevalence of these practices has exacerbated vulnerability to erosional processes, depletion of soil's organic carbon concentration and stock, loss of plant nutrients, negative soil budgets of nutrients and carbon, depletion and contamination of water, pollution of air, and the downward spiral of the quality and health of fragile and finite soil resources. In addition to scalping for brick making, widely practiced in South Asia and North Africa , the loss of topsoil is also serious under rapid urban encroachment, and development of infrastructure, and conversion to other non-agriculture uses.

Thus, there is a strong need for development of appropriate soil policy and enaction of legislation in support of the "Rights-of-Soil." Being a living entity and source of all terrestrial life, soil has a right to be protected, restored, used judicially, and thrive for both human well-being and also nature conservancy. Enhancing and sustaining soil health is also critical to advancing the Sustainable Development Goals (SDGS) or the Agenda 2030 of the U.N., specifically with regard to #2 (Zero Hunger), #13 (Climate Action), and #15 (Life on Land).

In this context, India must undertake appropriate steps to promote the followings:

1. Adoption of conservation agriculture (CA) based on no-till, residue retention as mulch, cover-cropping, and use of integrated nutrient management based on a combination of organic manure supplemented by chemical amendments,
2. Use of drip sub-fertigation (DSF) so that water and nutrients are applied directly to plant roots as and when needed,
3. Adoption of improved plant varieties which have built-in resistance to pests and pathogens, and creation of disease-suppressive soils to minimalize the need for inputs of pesticides,
4. Adoption of the "4 per Thousand" program of COP 21, inaugurated in Paris in 2015, to sequester soil organic carbon for adaptation and mitigation of climate change,
5. Incentivize farmers ,through payments for ecosystem services, for adoption of CA and DSF to sequester SOC, save water, avoid eutrophication, and purify air by avoiding the in-field burning of crop residues, and save land for nature,
6. Identification of alternate sources of clay for brick making (i.e., mine subsoil at key locations in each district, use rice husk, fly ash, and cement blocks) so that the finite and precious topsoil is protected,
7. Demarcation, zoning and protection of agricultural soils against non-agricultural uses, and adopting the policy of land degradation neutrality by restoring degraded soils and reducing risks of new land/soil degradation,
8. Assessment and publication of the "State of the Soil Health" report of India every five years beginning with 2020,
9. Reduction of food waste by improving storage, increasing shelf-life, and enhancing value addition by food processing, and
10. Develop National Soil Restoration Act, and Rights-of-Soil Act for protecting, restoring, and sustaining soil health.

I wish you all the best deliberations for the international conference on "Soil and Water Resource Management for Climate Smart Agriculture and Global Food and Livelihood Security," from the 5th to the 9th of November 2019 at the NASC Complex in Pusa, New Delhi.

Rattan Lal
The Ohio State University
Columbus, OH, USA

10th September, 2019

Ms. Clare Lindahl,
CEO,
Soil and Water Conservation Society

Message

The Soil and Water Conservation Society commends this joint international endeavor to provide a forum to discuss and take action on soil and water resource management to promote climate smart agriculture and ensure global food and livelihood security.

It is essential to hold conferences that bring people together from around the world to share research and experiences. While natural resources concerns are localized, the degradation of our soil and water have a global impact. Conservation efforts and effects span places, people, cultures, and landscapes, and there are lessons to be learned by all from the successful partnerships created by one another to implement solutions. This conference allows for learning and dialogue about the ecosystem challenges faced across the globe and facilitates individual actions and partnership opportunities to enact change at a local and global scale. It is these types of forums that allow conservation professionals to come together to discuss successes and challenges, combat shared obstacles, and accelerate conservation efforts.

Congratulations on successfully assembling this conference and for the outcomes sure to follow such an important forum. We have great confidence attendees will set intentions for this event and its lasting impact will ripple across the world.

Clare Lindahl

क. अलगुसुन्दरम
उप महानिदेशक (अभियांत्रिकी)
K. Alagusundaram
Deputy Director General (Engineering)
&
I/c Deputy Director General (NRM)

भाकृअनुप
ICAR

भारतीय कृषि अनुसंधान परिषद
कृषि अनुसंधान भवन–II,
पूसा, नई दिल्ली–110 012
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAVAN-II,
PUSA, NEW DELHI-110 012

Dated: 21.10.2019

Message

Soil and water conservation technologies have been the major driving force for increasing agricultural productivity and development of nations. Hydrological behavior of water domains are getting changed due to climate change which will play crucial role in managing water resources. Recent trends in rainfall pattern its distribution and changes in hydrological regimes have presented complication in efficient planning and management of water resources. In the past, the choice of technologies and their adoption was to reduce the soil erosion, rehabilitating degraded lands and enhance the soil moisture retention and subsequent enhancement in yield. Hence, developing an interface among academicians, researchers, government departments, policy makers, farmers, industry and other stake holders will be useful to prepare the road map for developing farmer's friendly soil and water conservation technologies for mitigating climate change impact on soil and water resources. In this context, International Conference on Soil and Water Resources Management for Climate Smart Agriculture and Global Food and Livelihood Security which is organized from 5-9 November, 2019 at New Delhi is timely and praiseworthy.

It is hoped that the deliberations and discussions during the Conference will come out with concrete recommendations that will be useful in developing strategies, demand-driven research programmes and an action oriented road map.

I extend my warm wishes for the success of the International Conference.

21/10/19

(**K. Alagusundaram**)

Ph: 91-11-2584 3415, Fax: 91-11-2584 2660; E-mail: ddgengg@icar.org.in

Prof. Dr. S.H.R. Sadeghi
President, Watershed Management Society of Iran (http://www.wmsi.ir/)
Professor, Department of Watershed Management Engineering,
Faculty of Natural Resources, Tarbiat Modares University **(TMU)**,
Noor 46417-76489, Mazandaran Province, Iran,
E-mail: sadeghi@modares.ac.ir

Message

I as the President of Watershed Management Society of Iran and a professor in department of Watershed Management Engineering at Tarbiat Modares University am very privileged to welcome to all participants of the of the Joint International Conference on "**Soil and Water Resources Management for Climate Smart Agriculture and Global Food and Livelihood Security**" jointly organized by Water Conservationists (WASWAC), International Soil Conservation Organization (ISCO) and Soil Conservation Society of India (SCSI) from 5-9 November, 2019 at NASC Complex, Pusa, New Delhi (India). Incontestably, thinking about simultaneous fulfilment of watershed balance and human needs is a vital task for decision makers, politicians, and experts to properly govern declining situations of the biotic and abiotic resources at different scales. In this direction, holding scientific gatherings on the management of two important commodities of soil and water while considering global and livelihood security certainly facilitate appropriate platform to propose new ideas and exchange valuable experiences among peoples with various backgrounds, living standards, and even governmental situations. Such issues need more considerations in developing countries due to ever-increasing population and uncontrolled developmental activities to make balance among all contradictory sectors in the ecosystems.

It is therefore needed to overcome existing myopia in the management of soil and water resources through propagating applied and scientific outcomes resulted from promising and fruitful gatherings to bring as many as scientists around a table to elucidate scientifically based practical solutions for the existing issues in the world to convince politicians, decision makers, planners, practitioners and even end users. It is ultimately hoped that all stakeholders proportionate their needs and expectations to holistically conserve all resources as precious heritance for the forthcoming generations. On this occasion I profoundly extend my thanks and greetings to all those collaborated with the conference and wishing them all the best.

Yours Sincerely

Professor Dr. S.H.R. Sadeghi,
Sep. 2019, Iran

Prof Li. Rui
President,
World Association of Soil and Water Conservation (WASWAC)

Message

I am very pleased to welcome all of you to participate in the Joint International Conference of WASWAC 4th World Conference, ISCO 20th Conference and SCSI 4th International Conference on behalf of the World Association of Soil and Water Conservation (WASWAC). The World Association of Soil and Water Conservation was founded in 1983 and its main mission is to promote soil and water resources being better used in the world. It has thousands of members from more than 120 countries. WASWAC is playing an increasingly important role in soil and water conservation of the world.

Soil erosion is the most predominant form of soil degradation. While the severity of soil degradation and its adverse economic and ecological effects are widely recognized. Global estimates of land area affected by degradation range from 1 Gha (Gha =104 km^2) to 6 Gha. An estimated 1.3 to 1.5 billion people worldwide are affected by land degradation. In recent years the earth is facing more and more challengers and pressures, such as climate change, population explosion, environment pollution, ecological degradation and economic / energy crises. Soil and water loss has become one of the most severe environmental problems to threaten the safety of human living and developing in the world. On the other hand, the people who live in the soil eroded areas have gained a lot of achievements and accumulated many successful experiences. Many countries in the world have taken corresponding countermeasures and actions to control the serious soil erosion, and have achieved good results.

This joint conference will be focused on soil and water resource management for climate smart agriculture, global food and livelihood security. This joint conference is one of the biggest events of soil and water conservation of the world in 2019. During the conference it is expected to discuss the new challenges to soil and water resources, Land degradation processes and mechanism, new technologies, and other important issues related to soil and water conservation. All participants will exchange and share their research achievements and experiments from each other. I believe this conference will play an important role to promote soil and water conservation in the world.

In the past more than 2 years the organization committee and working team from Soil Conservation Society of India have done a lot of hard work for the conference. Also many organizations, co-sponsors have made a great support and contributions to the conference. Here I would like to express sincere thanks to all those who have been involved in organizing the conference.

I wish the joint conference will be successful and everyone will have a good time in New Delhi!

Li Rui

SOIL CONSERVATION SOCIETY OF INDIA, NEW DELHI

Dr. Suraj Bhan
President, SCSI

Message

I am happy that **World Association for Soil and Water Conservation** (WASWAC), Beijing, China & **International Soil Conservation Organisation** (ISCO), USA are jointly organizing the 4th International Conference on ***"Soil and Water Resources Management for Climate Smart Agriculture, Global Food and Livelihood Security"*** with **Soil Conservation society of India**, during November 5th-9th, 2019 at 'National Agricultural Science Centre' (NASC) Complex, Pusa, New Delhi, India

I consider that the Soil and water management under the changing climate for agricultural, food, environmental, energy and livelihood security is a pre-requisite for sustainable agricultural production. The socio- economic, environmental, energy and livelihood impacts are significant to achieve sustained agricultural growth. Natural resources are critically important components of life support system, the efficient conservation and management of which are vital for achieving food and livelihood security with economic growth and rural development.

The organization of International conference on such an important topic is timely and I appreciate the concern of not only Indian but international agencies, scientists and other stake holders. The deliberations at the conference will bring out the current status and the technologies for moving forward. The recommendations coming out the five days in interact discussion will help in achieving efficient management of our Natural Resources with a view of improving the livelihood security of farming community under changing climatic scenario. I am sure that the organizing committee and the members of the society will ensure a successful conduct of the conference

01-11-2019
New Delhi

(Suraj Bhan)

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Messages

Articles

ADAPTATION AND MITIGATION OF CLIMATE CHANGE IN INDIA BY SOIL CONSERVATION AND RESTORATION

Rattan Lal*

Abstract: *Soil degradation in India must be addressed because of its strong adverse effects on human wellbeing and the environment. Indeed, there is a strong link between the quality of soil, water, and air. Thus, soil degradation also leads to contamination/eutrophication of water, pollution of air, and deterioration of human health. India must seize an opportunity of implementing some global initiatives with implications to soil health. Notable among these are: 1) "4 per Thousand" initiative launched at COP 21 in Paris in 2015 and focused on sequestration of soil organic carbon at the rate of 0.4% per year to 40 cm depth, 2) Sustainable Development Goals (SDGs) of the U.N. or the Agenda 2030 launched in 2015, and with three goals (SDG #2, #13, and #15) directly related to soil health, and 3) Land Degradation Neutrality, related to SDG #15 of Life on Land, and launched by the U.N. Convention to Combat Desertification (UNCCD). With as much as 146-174 M ha (44.3% to 53.0% of the total land area) affected by one or another degradation process, India must launch a program of monitoring the State-of-Soil report every five years. Further, farmers must be compensated for the provisioning of ecosystem services such as restoring soil carbon stock, increasing quality and availability of water, and enhancing biodiversity. Legislation must be enacted for protecting "Rights-of-Soil," and education curricula revised to incorporate teachings on soil and the environment from primary school to post-graduate level. Religious organizations may be encouraged to highlight the importance of soil as depicted in scriptures. Translating knowledge of soil science into action through policy intervention is critical.*

Key words: *Global warming; soil carbon sequestration; soil health; Rights-of-soil; SDGs; 4PT*

The severe problem of soil degradation in India, the decline in soil quality because of adverse changes in soil properties and processes (i.e., physical, chemical, biological, and ecological), is being exacerbated by the current and projected climate change. Some estimates indicate that as many as 147 million hectare (M ha) of land (45% of the total land area) is affected by a range of degradation processes including water erosion (94 M ha), wind erosion (9 M ha), acidification (16 M ha), inundation or flooding (14 M ha), salinity (6 M ha), and others (7 M ha) (Lal, 2007b;Bhattacharyya et al., 2015). Recent estimates indicate soil degradation affecting 174 M ha or 53% of the total land area (Sharma et al., 2018). These estimates neither include land areas characterized by severe depletion of soil organic carbon (SOC) concentration and loss of biodiversity nor those drastically disturbed by brick making and mining.

The current population of India of 1.35 billion, increasing by 17 million per year, is projected to be 1.65 billion by 2050 (U.N.,2018). India supports 18% of the world's human population and 15% of the world's livestock population on merely 2.4% of the world's land area. With a total net cultivated land area of 140 M ha, the present per capita land area of 0.10 ha may decline to <0.08 ha by 2050 even if there is neither any urban encroachment nor any severe degradation. As many as 86% of farmers are small land holders (< 2 ha), who manage 146 million farms. India is also home to a food-insecure population of ~350 million out of a total of 486 million food-insecure in South Asia and 821 million in the world (FAO, 2018). India's food grain production increased from about 50 million ton in 1950 to 285 million ton in 2018, and the rate of increase in food grain production exceeded that of the population growth. However, there has been a serious problem of degradation of soil, eutrophication and depletion of water and pollution of air. Therefore, improved agriculture and sustainable management of natural resources must be integral to any strategy of addressing anthropogenic climate change, depletion and eutrophication of water, pollution of air, extinction of biodiversity, and above all, achieving food and nutritional security of India's growing and

Carbon Management and Sequestration Center, The Ohio State University, 210 Kottman Hall, 2021 Coffey Road, Columbus, OH 43210, USA, Email: Lal.1@osu.edu; Phone: 614-292-9069

increasingly affluent population. Thus, it is critical that India reconciles the need for achieving food and nutritional security with the absolute necessity of restoring degraded soil (Lal, 2007a), reducing risks of additional degradation, achieving land degradation neutrality by 2030 and improving the overall environment.

Improved agriculture is also critical to achieving Sustainable Development Goals (SDGs) on the Agenda 2030 of the United Nations (U.N., 2015). Similar to the Millennium Development Goals (MDGs), achieving SDGs may also be a challenging task. Yet, the importance of restoring soil and natural resources to advancing SDGs cannot be over-emphasized. Soil conservation and restoration is especially critical to achieving SDG #2 (Zero Hunger), SDG #13 (Climate Action) and SDG #15 (Life on Land). Sustainable management of soil ,through adoption of conservation- effective measures which also lead to sequestration of soil organic carbon , is pertinent to advancing the "4 per Thousand" (4PT) initiative launched at the COP21 of Paris in 2015 (INRA, 2015).Thus, the objective of this article is to deliberate the importance of soil conservation and restoration to adaptation and mitigation of climate change in India, South Asia and beyond.

Managing India's Gaseous Emissions

India aims to reduce emissions intensity of its Gross Domestic Product (GDP) by 20-25% below 2005 levels by 2020, and 30-35% below 2005 levels by 2030. India is also aiming at increasing the share of non-fossil energy in total power generation capacity to 40%, and creating and additional C sink of 2.5-3 PgCO_2 eq by improving forest cover (UNEP – Emission Gap Report, 2019). These strategies would lead to emission levels of 4.4-7.5 PgCO_2 eq/yr and 4.2-5.9 PgCO_2 eq/yr by 2030 for the unconditional and conditional Nationally Determined Contribution (NDC) scenario, respectively (UNEP, 2019). Despite these commendable efforts, India can do a lot better through adoption of recommended land use, soil restorative and best management agricultural practices.

While following the strategies of reducing emission intensity are pertinent, these approaches can be supplemented and strengthened by making the agricultural sector a solution to addressing the critical environmental issues. Indeed, conservation and restoration of degraded soil is essential to addressing environmental issues of India (and those of the world) such as adapting and mitigating the anthropogenic climate change, reversing soil degradation trends and achieving land degradation neutrality by 2030, and re-carbonizing the soil and vegetation. Conversion to restorative land uses and adoption of sustainable farming/cropping systems that create a positive soil/ecosystem carbon budget are critical to addressing the climate change. Thus, soil restoration and conservation should be given a high priority in India (as well as in South Asia and elsewhere) because of their numerous co-benefits, especially those with regards to improving water quality and renewability, promoting nutrition-sensitive agriculture, strengthening biodiversity, alleviating poverty, and eliminating hunger in a changing and uncertain climate.

Anthropogenic activities affect more than 70% of the ice-free land (IPCC, 2019), and human use 25-33% of the land's potential net primary productivity (NPP) for food, feed, fiber, timber, and energy. Consequently, anthropogenic land use has been and is among major sources of greenhouse gases (GHGs) and is a principal factor affecting the global carbon cycle (GCC). Accelerated soil erosion and other degradation processes affect ~25% of the world's ice-free land area. The risks of soil degradation are exacerbated by the climate change and extreme events. Thus, adopting techniques of Sustainable Land Management (SLM) can reduce the risks of soil and environmental degradation (Lal, 2011). Further, resource use for agriculture is already high including 70% of global freshwater withdrawal, 5 billion hectare of land area used for cropland and grazing land, and 200 million Mg of fertilizer use, and other input (Lal, 2019b). An important strategy to enhance food security is to reduce food wastage, estimated at 25-30% globally (IPCC, 2019),and perhaps even more in India.

Accelerated Soil Erosion as a Source of Greenhouse Gases

Accelerated soil erosion, caused by a range of agents or sources of energy (i.e., rain drop, overland flow, steam flow, ocean waves, glacier movement, wind, gravity, tillage), has four stages: detachment, transport, redistribution over the landscape and deposition. Soil erosion aggravates emissions of GHGs at all four stages (Figure 1, Lal, 2003;2005;2017;2018a; 2019a). Breakdown of structural aggregates exposes the soil organic carbon (SOC) hitherto encapsulated and protected from microbial processes. Gaseous emissions are also affected by the transport and redistribution of SOC and sediments over the landscape because of changes in soil temperature and moisture regimes and because the labile fractions (particulate organic carbon and dissolved organic carbon) are prone to microbial processes. Whereas some of the SOC, associated with the buried sediments and contained in saturated soil conditions, may be less prone to decomposition, some of the SOC at depositional sites may be prone to methanogenesis and emission of methane (CH_4). Similarly, SOC and the nitrogenous compounds associated with it, may also be prone to nitrification and denitrification processes at the redistribution and depositional sites and lead to emission of nitrous oxide (N_2O). Both CH_4 and N_2O have higher global warming potential (GWP) than that of CO_2 and their emission aggravate the global warming.

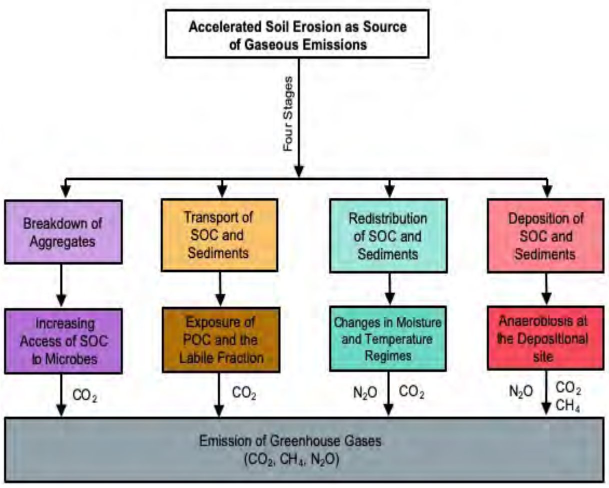

Figure 1. Accelerated soil erosion as a source of greenhouse gases.

Soil Conservation and Restoration for Adaptation and Mitigation of Climate Change

Reversing the soil degradation trends by adoption of the practices of SLM (Lal,2011) and related conservation-effective measures can lead to re-carbonization of the soil and transfer of atmospheric CO_2 into the SOC pool in degraded and depleted soils of India (Figure 2; Lal, 2004;2009;2010;2015a;2017). Restoring SOC is also important to increasing climate resilience in soils and agroecosystems (Lal, 2016b), especially against the drought -flood syndrome and the projected increase in frequency and intensity of extreme events. Adoption of conservation effective measures, while conserving soils, also store water in the root zone, enhance water use efficiency, improve productivity (Lal, 2009a;d;2010b;2016a;2017b), and enhance SOC sequestration. Similarly, reclamation of saline soils is also important to improving NPP and enhancing SOC sequestration (Lal, 2010a). Increase in productivity enhances SOC sequestration especially if the crop residues and root biomass are returned to the soil through adoption of a system-based conservation agriculture (Lal, 2015a).

Figure 2. Conservation of soil and water and restoration of eroded soils as a sink of atmospheric carbon dioxide (NPP=Net Primary Productivity; MRT=Mean Residence Time)

Improving SOC in depleted and degraded soils of India is also critical to enhancing soil health, increasing use efficiency of water and nutrients and improving productivity and sustainability (2006;2008). Indeed, restoration of degraded soil is the win-win-win option of harnessing numerous co-benefits through solution under foot and the power of soil to addressing the issues of regional, national, and global significance.

Soil Conservation and Sustainable Development Goals

Conservation and sustainable management of soil is also critical to advancing several SDGs. Pertinent SDGs in relation to soil management are SDG#1 (End Poverty), SDG #2 (Zero Hunger), SDG #13 (Climate Action) and SDG #15 (Life on Land) (Figure 3). Being an agrarian nation with strong commitment to advancing SDGs, promoting sustainable agriculture and restoring degraded and eroded soils is a high priority for India and other countries in South Asia. The food security in India (Lal, 2009c), for the growing population of 1.35 billion and increasing by 17 million per year, necessitate restoration of degraded soils through increase in SOC concentration and stock (Lal, 2006). Thus, implementing the "4 per Thousand" initiative (Lal, 2018c) is also pertinent for India towards realizing the vast global potential of sequestering carbon in terrestrial ecosystems by the end of the 21st century (Lal et al., 2018). Recycling waste and by-products of agricultural industry can play an important role in soil carbon sequestration and reducing dependence on agricultural chemicals (Lal, 2017b).

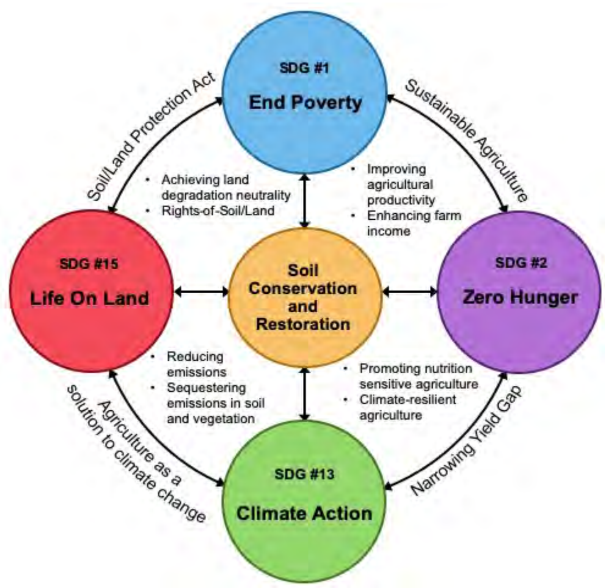

Figure 3. Advancing Sustainable Development Goals through soil and water conservation and restoration of degraded and depleted soils.

Soil conservation and restoration of degraded soils, in India and elsewhere in the world, is also pertinent to achieving the land degradation neutrality (LDN). The concept of Zero Net Land Degradation ,originally proposed at the Rio+20 Conference in Brazil in 2012 (Lal et al., 2012), is now officially adopted by the UNCCD as LDN (Orr et al., 2017).The scientific conceptual framework for accomplishing LDN (Cowie et al., 2018), needs to be fine-tuned and validated for local conditions in South Asia in general and India in particular. However, the LDN must be accomplished in India both for economic and environmental reasons, and also for accomplishing the SDG #15 of improving the "Life on Land."

Policy Interventions for Promoting Soil Conservation

Implementation of global issues (e.g., 4PT, SDGs) in India may necessitate critical policy interventions such as enacting "Rights-of-Soil" (Lal, 2019c). Being a living entity, soil also has rights to be managed judiciously and protected against degradation and pollution. Thus, soil must be restored and managed sustainably so that it can thrive and flourish for provisioning of ecosystem services both for the wellbeing of the humanity and nature conservancy. The concept of the "Rights-of-Soil" is in accord with that of the Rights-of-River Ganges, Rights-of-Himalayas, and that of nature in general.

The legal approach can be complemented by involving all the religious organizations in India. Scriptures of all major religions of India (e.g., Hinduism, Islam, Buddhism, Christianity, Sikhism and Judaism) preach protection and worship of soil, water, air, trees, biodiversity and nature (Lal, 2013). Indeed, nature worship is a part of India's Sanskriti. Thus, religious organizations may be encouraged to preach soil restoration and conservation of water and biodiversity to their followers and faithful. Such a strategy would be in accord with the concept of the ethics of soil conservation (Lal, 2018e).It is also important to realize that soil is the only site in the universe (e.g., the soil-root interphase at a nanoscale called the rhizosphere)where the death is resurrected into life. The minerals (N, P, K, Zn, Cu, I, Mo, As, etc.) released from the decomposition of the remains of plants and animals are absorbed by plant roots and enter into the food chain that sustains all terrestrial life on the planet Earth.

Soil Conservation and Management in Education Curricula

Soil must be taught in the curricula beginning with the primary school and onward to the post graduate level in the college. Special books must be prepared for the primary school children (Apfelbaum, 2019), and provisions must be made for the hand-on experiences in studying soil, its properties, and ability to support life. It is also important to enhance awareness of the policy makers, civic societies, and the general public regarding the importance of soil to the welfare of the society and of nature. The concept that the "health of soil, plants, animals, people, and the environment is one and indivisible" must be promoted. It is critical that all humanity must understand that soil properties and its productive capacity must never be taken for granted.

Translating Knowledge of Soil Science to Action

India has made a commendable progress in enhancing food grain production from about 50 million ton in 1950 to about 280 million ton in 2018 .An objective dialogue must be established between the policy makers and researchers and educators in soil science. One objective is to translate knowledge of soil science into action. The "4PT" adopted at COP21 in Paris (INRA, 2016) is an example of translating science into action. Advancing SDGs or the Agenda 2030 (U.N., 2015) also requires an earnest effort on part of the policy makers to translate science into action. Towards this goal, the scientific information must be presented to the policy makers and land managers in a manner that they understand and relate to it. In addition to presenting their results in peer-reviewed journals, soil scientists must also communicate their findings to the policy makers in a language that is easy to comprehend that will enable them to take appropriate action that promotes the recommended land use and soil/water management options. Important among these are promotion of conservation agriculture with the retention of crop residue mulch and use of drip sub-fertigation for irrigated agriculture, a ban on in-field burning of biomass and flood irrigation, and immediate elimination of the destruction of topsoil to 1-m depth for brick making.

Farmers must be rewarded for the provisioning of ecosystem services such as increasing SOC in the root zone, improving quality and renewability of water resources, enhancing quality of air, and strengthening biodiversity. Such payments, based on a just and transparent system with an assessment of realistic societal value of natural resources (Lal, 2014), are neither subsidies nor handouts or charities. These payments are based on the services rendered by the farmer to the nation and the global community.

Translation of science into action can be facilitated by the awareness among policymakers regarding the strong interconnectivity between the quality of soil, water, and air (Figure 4). Thus, degradation of soil also leads to degradation of water and that air. Indeed, the health of soil, plants, animals, people, and the environment is one and indivisible. It is this knowledge, that must be translated into action in India, South Asia and the world.

Figure 4. The inter-connectivity between the quality of soil, water, and air in relation to the overall environment: The soil-water-air quality-nexus

CONCLUSIONS

Soil conservation and restoration must receive the highest priority in India. The conservation-effective strategy of reversing soil degradation trends on 174 M ha of land area is also pertinent to implementing the "4PT" initiative of COP 21, advancing SDGs of the U.N., and achieving LDN of UNCCD. These can be achieved through implementing some Do's and Don'ts in Indian agriculture (Table 1).

Table 1. Some important Do's and Don'ts of soil conservation and restoration in India (modified from Lal, 2018f).

Do's	Don'ts
1. Adopting conservation agriculture	1. In-field burning of crop residues
2. Recycling of crop residues and animal waste on land	2. Flood-based irrigation
3. Providing clean cooking fuel for rural community	3. Removal of topsoil for brickmaking
4. Protecting prime agricultural land against urbanization	4. Broadcasting fertilizer in water or on the soil
5. Planting trees on hilly land >7% slope	5. Plowing and puddling of soil
6. Revising curricula at school and college level to include soil and environmental education	6. Traditional fuels (cow dung, crop residue, wood, etc.)
7. Paying farmers for ecosystem services	7. Uncontrolled grazing free roaming cattle

Do's	Don'ts
8. Encouraging religious organizations to preach land ethics and protection of soil and nature 9. Increasing dialogue with policymakers 10. Involving communities and panchayats in soil restoration	8. Storage of grains in the open under a plastic cover 9. Subsidies for flood irrigation and nitrogen fertilizer 10. Use of crop residues for other uses

The implementation of the Do's and Don'ts outlined in Table 1 require the strengthening of communication between soil scientists/agronomists on the one hand and policymakers, general public, and religious leaders on the other.

There is also a need for change in the mindset of the general public regarding the social value and age-old traditions. Soil, water, vegetation, air, animals, nature, and agriculture must be given the respect that these elements deserve. These precious but fragile endowments must never be taken for granted.

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PRELIMINARY PROGRESS ON GLOBAL SOIL EROSION ASSESSMENT

Rui Li[1*], Baoyuan Liu[1, 2], Qinke Yang[3], Shaoshan An[1], Juying Jiao[1], Minghang Guo[1], Chunmei Wang[3], Guowei Pang[3], Lei Wang[3], Hongming Zhang[4] Panagos, Panos[5] and Borrelli, Pasquale[6]

Abstract: Currently many scientists and agencies are working to perform global soil erosion assessments at various scales. Here we would like to introduce the preliminary progress of the Project (Global Soil Erosion Assessment) implemented by a joint group of scientists from China and Europe. In the past 2 years the project was mainly concentrated on the driving factors of global soil erosion. We selected the newest available datasets and suitable methods to calculate and extract the soil erosion factors. In order to get better data of soil conservation practices and more realistic soil erosion assessment, the sampling survey based on high resolution Remote Sensing images and field checking was conducted. Integrated the data (natural factors and practices of soil conservation), water erosion rate is calculated at each sampling unit based on the Chinese Soil Loss Equation (CSLE). This method has been tested in the Pan Third Pole area and the results are satisfying suitable for erosion assessment at regional scale.

Keywords: Global soil erosion assessment, Erosion factors, sampling survey, high resolution, water erosion

Introduction

Soil erosion is one of the global key environmental problems, which leads to serious land degradation and threat to sustainability of agriculture. Many scientists and agencies are working to perform soil erosion assessments at various scales. Panagos and his team (2015) made a new assessment of soil erosion by water in Europe. In China the national soil erosion survey was organized and the new inventory was produced. In a later study Borrelli et al. (2017a) investigated global soil erosion dynamics by means of high-resolution spatially distributed modelling (ca. 250 × 250 m cell size). As a result the technology of regional soil erosion assessment has been improved. Based on these achievements World Association of Soil and Water Conservation (WASWAC) initiated a research project on global soil erosion assessment under the support from Chinese Academy of Sciences. In 2018 the project was developed as an international cooperation project between China (ISWC) and Europe (JRC). The objectives of the project are to make a global soil erosion inventory and develop suitable method for global soil erosion assessment.

Methodology

1. Extraction and calculation of natural soil erosion driving factors

We selected the newest available datasets and selected (or developed) suitable methods to calculate and extract the regional erosion factors such as rainfall erosivity (R), soil erodibility (K),

[1] State Key Laboratory of Soil Erosion and Dryland Farming on Loess Plateau, Institute of Soil and Water Conservation, CAS/MWR, NWAFU, Yangling, Shaanxi Province, China

[2] State Key Laboratory of Earth Surface Processes and Resource Ecology, Faculty of Geographical Science, Beijing Normal University, Beijing 100875, China

[3] Shaanxi Key Laboratory of Earth Surface System and Environmental Carrying Capacity, College of Urban and Environmental Sciences, Northwest University, Xi'an 710127, China

[4] College of Information Engineering, NWAFU, Yangling, Shaanxi Province, China

[5] European Commission, Joint Research Centre,E.Fermi 2749,IT-21027 Ispra, Italy

[6] Environmental Geosciences, University of Basel, Basel CH-4056, Switzerland

the slope length and steepness factor (LS), and FVC (land-use and cover, partially C) at the global scale. R was calculated based on daily rainfall product from Climate Prediction Center (CPC) with resolution of 0.5° from 1986 to 2016. In order to improve the accuracy, the datasets for global R is calculated based on sub-hourly and hourly pluviographic records interpolated spatially interpolation using advanced techniques. K has being calculated based on RUSLE2 algorithm and 250m Soil-Grids. The land use and cover have been analyzed using agricultural inventory data, conservation agriculture statistics, remote sensing data and a probabilistic land use allocation approach. The LS has been calculated mainly from 1 arc second (ca. 30m at the equator) SRTM and Aster GDEM. As DEM resolution can influence LS accuracy, a down scaling model is to be used to downscale LS to 10m, taking various sources of relative high resolution DEMs at sampled typical areas for compared data source.

2. Extraction of soil conservation practices information

It is a very big challenge for us to get the spatial data of practices of soil conservation. But it is very important for assessment of actual soil erosion. In order to cope with this demand we used the method of CSLE in which the soil conservation practices are defined as BET. B stands for biological measures, E stands for engineering measures and T stands for tillage measures. We selected the sampling units (small watersheds or rectangular box) based on high resolution images in research areas. Then the soil conservation practices were extracted from image interpretation and the field checking,

3. CSLE sampling survey method

In order to get better data of soil and water conservation practices and more realistic soil erosion assessment, the sampling survey based on high resolution Remote Sensing images (such as Google Earth images) and field checking was conducted. Integrated the data (natural factors and practices), water erosion rate is calculated at each sampling unit (Liu, et al. 2015, Yin, et al. 2018, and Zhu et al, 2019). The result provides a good base for the regional soil erosion assessment. Using this method the quantitative assessment of actual soil erosion status can be realized.

Results

1. Global soil erosion driving factors extraction

At the first period, R was calculated based on daily rain fall product from Climate Prediction Center (CPC) with resolution of 0.5° from 1986 to 2016. The annual average R value (Rcpc) and the ratio of R per half month were calculated after removing the non-erosive rainfall (< 10mm). R value was also calculated from the daily rainfall data of 2358 meteorological stations provided by China Meteorological Administration (Rchn). Later, the dataset for R is calculated based on sub-hourly and hourly pluviographic records interpolated spatially interpolation using advanced techniques. For global soil erodibility (K) was calculated based on SoilGrids 250 dataset and has been checked with observed the reports in literatures. The highlight of the global soil erodibility datasets include:(1) Optimizing the algorithms: three commonly used algorithms for soil erodibility algorithms have been used and is possible to user to select optimal output.(2) High resolution: the calculation is based on the latest version of dataset products of SoilGrids with high resolution (for global scale), the macro geo-differentiation and local variations are all well-presented.(3) New developed themes and modification: based on PTF ideas and global soil profile database (also some record from the FAO world soil map), the soil structure class type has been generated and used in the calculation of K_USLE K_RUSLE2; the impacts of coarser sand content and stoniness can be taken into account (modification procedure has been go through).

LS factor is to be derived from 1arc SRTM elevation data globally. The result of the slope and slope length can be downscaled by histograms matching method (Yang, David et al. 2008) to 10m resolution. L is slope length (m), S is slope steepness (°), L and S are often combined as LS, the topographic factor. The method incorporates a multiple-flow algorithm and the detection algorithm for the beginning and end of each slope. CSLE uses an equation different from the RUSLE for steeper slopes (>10°) to calculate S and a different slope-length exponent to calculate L.

2. Extraction of soil conservation practices

In order to get better data of soil conservation practices and more realistic soil erosion assessment, the sampling survey based on high resolution remote sensing images (such as Google Earth images) and field checking was conducted. The comparative analysis of land-use types and GLS30 data for Sampling Unit (SU) interpretation shows that the similarity of two set of data in most area is greater than 0.75, and the results of sample interpretation can represent the macroscopic structure of land-use. The results of the interpretation were checked in the field by in typical sections in southern Tibet and northern Thailand. The results showed that the average of kappa coefficient and accuracy in Tibet was 0.7 and 80.04%, and the northern Thailand was 0.5 and 85.78%, respectively. All problems have been systematically corrected after the field work, so the accuracy of final data has been improved.

3. The application of CSLE Sampling survey for water erosion rate calculation

Integrated the regional factors and practices data, water erosion rate for each SU has been calculated using CSLE, the results show that the calculated results (a map of soil loss rate) can reflect the spatial heterogeneity of soil erosion. There is a significant difference between potential soil loss (RKLSB) and actual soil loss rate (RKLSBET). This method is using in the Pan Third Pole area and the typical surveying examples showed that the quantitative assessment of actual soil erosion status can be realized.

Discussion

1. The available databases in the world can meet the requirements to calculate and extract natural driving factors of global soil erosion assessment. It is necessary to develop a special division map of soil erosion which can show the regional differences of physical climate, geography and geomorphology.
2. There are many available digital data to be used for slope gradient and slope length (LS) extraction and calculation. As detected by our research, we suggest a downscaling processing in LS calculation based on lower resolution DEMs and sampled higher resolution DEMs, which will improve the accuracy of LS where the higher resolution DEMs are not available .
3. Practices of soil conservation are very important to assess the actual soil erosion. Now we have obtained dataset in about 20000 sampled units in the Pan Third Pole area using Google Earth images. The results showed soil conservation practices can be extracted. But it is necessary to have more local field observation data.
4. Integrated the data (natural factors and practices of soil conservation), water erosion rate is calculated at each sampling unit based on the Chinese Soil Loss Equation (CSLE). This method has been tested in the Pan Third Pole area and showed that the results are satisfying suitable for erosion assessment at regional scale.

Conclusions

There are available databases for extraction of global soil erosion driving factors. It is predicted that the recommended data and methods for global soil erosion assessment will be proposed from our project. Integrated the data (natural factors and practices of soil conservation), water erosion intensity is calculated at each sampling unit based on the CSLE. The results showed it is satisfying suitable for erosion assessment at regional scale. But it is necessary to have more local data and need more field testing in different geographical regions.

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SIGNIFICANT PROBLEMS AND ALTERNATIVE STRATEGIES OF WATERSHED MANAGEMENT AND DEVELOPMENT

Suraj Bhan*

Land, which includes soil, biological and water resources, is one of the principal natural resources providing eco-services for sustenance of life. Natural resource degradation is a major cause of global change in climate and life-support systems of human societies. Therefore, Natural Resource Management (NRM) has attracted world attention of highest order for, broadly, assuring sustenance of the ecological services that are life support systems for all living organisms, and particularly, augmenting agricultural development, as agricultural research. And external input-intensive technological innovations that had succeeded in ushering a population growth matching global agricultural productivity are now nearing their potential limits. The reasons for this alarming agricultural scenario are: (i) decreasing availability of new productive lands and usable water-resources, (ii) the alarming rates of on-going human-induced soil- and water-resources degradation, (iii) the increasing encroachment on and over-stressing marginal, fragile and degradation-vulnerable lands, (iv) the inability to enhance adoption of conservation-effective land-use systems at rates sufficient to overtake on-going degradation, and (v) continuing expansion of earth population at alarming rates.

India having the second largest population of the world (18%) owns only 2.4% of the world's land resource. As per harmonized database on land degradation, 120.72 million ha area of India is subjected to various forms of land degradation, with maximum (68.4%) contribution by water erosion (82.57 million ha). Potential erosion rates estimated for different states indicate that 49% area has erosion rate of >10 tonnes/ha/year while 13% area falls in very severe category (>40 tonnes/ha/year). However, the permissible soil-loss rate, depending on soil quality and depth, is estimated to vary from 2.5 to12.5 tonnes/ha/year. About 57% area of India has soil-loss tolerance limit of <10 tonnes/ha/year, while about 7.5% area has a soil loss tolerance limit of only up to 2.5 t/ha/yr.

India owns 4.2% of world's freshwater resource but supports 18% of global human and 15% of livestock populations. The country has 668 km^3 of utilizable water resources and will face water deficiency of 229 km^3 in 2050 even under low-demand scenario, which would increase to 396 km^3 under high-demand scenario. Based on the average requirement of water for various purposes, the situation is considered as 'water stressed' when per caput water availability ranges from 1,000 to 1,700 m^3 per year, and it is considered 'water scarce' when the availability reduces to less than 1,000 m3 per year. As water availability varies widely within India as a result of rainfall, groundwater reserve and proximity to river basins, most of Indian States would reach water stressed condition by 2020 and water-scarce condition by 2025. Hike in frequency of occurrence of droughts over the recent years is an indicator of the worst scenario in future. The alarming magnitude of on-going and persistent natural resource and environmental degradation and its detrimental impacts worldwide indicate that fresh alternative strategies are needed for addressing natural resources management and environmental problems. Globally, there are sufficient resources of land and water to produce food over the next 50 years, but only if water for agriculture is better managed. This is so, because water is the most crucial input and acts as a catalyst to bring in ecological, social and economic revolution. Under conditions of limited water availability, 3 options exist for capturing additional water required to achieve higher food-production targets – **(a)** efficient management of blue water, i.e. water available in rivers, lakes, wetlands and aquifers to expand irrigation (blue water options), **(b)** better use of green-water, i.e. infield rainfall, naturally infiltrated rainwater and harvested local runoff (green-water options), and **(c)** exploration of virtual (imported) water options. Green-water use is about 4–5 times greater than consumptive blue-water use in global crop production. Hence full green-to-blue spectrum

Soil Conservation Society of India
National Societies Block G-4/A, NASC Complex, DPS Marg, Pusa, New Delhi – 110 012

of agricultural water-management options need to be exploited when tackling the increasing water gap in food production

PROBLEMS

The concept of watershed development started in India with a focus upon prevention of runoff and concomitant soil erosion to slow down siltation rates of reservoirs in medium and large river valley projects, and also mitigate flash floods. Now, it is widely considered to be the growth engine of rural development. Watershed development is a complex concept as it is not merely concerned with conserving soil, water and other natural resources, but is also with enhancing their productivity in a sustainable manner. This has implications about management of interface between different kinds of resources, interface between differently owned resources, and, exclusively, management of common property resources. Despite the success of watershed-development programmes in India, there are some critical problems that inhibit its potential to drastically change the rural scenario of India in many aspects which are described as follows for planning and implementation phases.

A. Planning phase

Weak institutional arrangements at project level

Experiences have shown that institutional arrangements at project level, such as project implementing agency (PIA) or local community-based organizations (CBOs), *viz.* watershed association (WA) and watershed committee (WC), play a pivotal role in successful implementation as well as sustainability of watershed-development programmes. The National Rainfed Area Authority (NRAA) has given a set of broad guidelines for selection as well as formation of the community-based organizations. However, the practice of entrusting watershed development to non-government organizations (NGOs) or incompetent watershed development teams of government or non-government organizations is prevalent to a large extent. Such institutions are unable to create favourable environment for watershed development in rural settings which leads to passive receipt of soil- and water-conservation technologies. Non-involvement or poor functioning CBOs give higher priority to individual benefits over community-based activities. Many a times, local level conflicts are the outcome of poor performance of local-level watershed institutions.

Declining trend of primary stakeholders participation in different phases of watershed development projects

Studies indicate that participation of primary stakeholders in watershed-development programmes was the highest during project planning phase, medium during implementation phase, and the least in withdrawal phase. The first constraint listed above may be a major contributor to it, but lack of technical competency of watershed development team in selection of most appropriate intervention points on priority by adopting efficient conflict resolution techniques is also an equally paramount constraint.

Absence of well defined process for securing participation

Participation of watershed community is important for success of any watershed-development project. There is no well-defined process for securing participation based upon documentation of successful implementations at grass-root level. Such a process will help in achieving the stated physical, financial, institutional and policy-related goals. In most of the cases, community participation is realized in cash and generally deducted from wage payment made to the labourers and not from the actual beneficiaries of the activities.

Lack of policy or law against saboteurs

Natural resource management projects invariably require collective action by stakeholders having usufruct rights. Many projects ultimately fail due to non-cooperation or sabotage by few affluent stakeholders having vested interests, e.g. utilization of limited water available for drinking and domestic use, for construction purposes and non-payment of contributions, dues etc. Their activities lead to loss of public money and loss of opportunity by sincere stakeholders to improve their livelihoods. There should be policy or even a law to check such stakeholders for benefit of the maximum number of those stakeholders that sincerely embrace the project for all-round benefits. Though the Common Guidelines of Watershed Development have explicitly assigned this responsibility to the Panchayati Raj Institutions (PRI) with a provision of forced closure of the project, but unfortunately, it could not be legalized owning to poor cooperation from higher level PRIs. Positive participation and cooperation required for improving rural employment scenario and enhancing rural income and rural livelihood security.

Poor identification of key drivers for watershed development success

Development of watersheds occurs in different agro-ecological and socio-economic settings. Therefore, identification of some key elements for the success of a watershed-development programme, which can be an individual (a leader or government officer), group (PRI or CBO) or highest priority intervention or their combinations is essential for sustainability of the programme. It requires highest level of social as well as technical skill combinations for which available experts are rarely available.

Non-harmony of village and watershed boundaries

Watershed and village boundaries need to be harmonized as the biophysical interventions are based on natural boundaries of the watershed, but the participation is based on village boundaries which are man-made. Therefore, there are likely beneficiaries living outside watershed boundary or even vice-versa. This creates a problem in execution of the project activities. Therefore, the boundaries of the two entities of the watershed concerned need to be harmonized.

B. Implementation phase

Lack of managerial skills

A project manager has to encounter a number of constraints/ challenges during implementation phase even in a well-planned project. This increases with the increase in inequality among the project stakeholders. The problems faced during project implementation phase are more related to management and social aspects than technical aspects. These problems can be tackled effectively and efficiently through application of management principles rather technical principles. The competency of presently available leadership in this aspect is primarily based on experience but requires building their capacity in application of project management instruments right from planning to withdrawal phase of the project.

Lack of expert technical manpower in state departments/KVKs/other institutions

Presently, state governments/KVKs are undertaking capacity building programmes in various departments such as agriculture, forest, soil conservation, watershed management etc., through orientation/ refresher courses at state-level training institutes such as State Institute of Rural Development (SIRD) etc. Some states have specialized training institutions, while others have given this responsibility to State Agricultural Universities. Some NGOs like SAUs, MYRADA and OUTREACH are also engaged in imparting training in watershed management. However, the manpower trained at these institutions lack both in terms of quality and quantity. Quality wise, majority of training institutes have autonomous departments with little or no field experience in the management of natural resources and watersheds, which being a complex phenomenon requires multidisciplinary approach. The trainers engaged do not possess requisite technical and practical knowledge to effectively implement projects related to management of natural resources and watersheds following integrated multidisciplinary approach. Proper monitoring and impact evaluation, based on scientifically developed indicators, is also lacking. Therefore, the curricula and training modules for different levels of stakeholders are either inadequate or do not employ modern tools and procedures such as Remote Sensing and GIS. There is absence of networking mode of training and lack of demonstration sites of successful/ model watershed-management projects for better understanding of the concept or technologies. Quantity wise, based on latest watershed-development guidelines of Government of India, it has been estimated that about 6,649 and 7,617 batches of watershed-management-capacity building training courses with 25 participants in each batch and of duration ranging from 3 days to 3 weeks, depending on level of training, need to be organized annually during the XII and XIII Plans to cope up with huge demand of trained technical manpower in various departments/agencies. The guidelines for watershed-development projects implemented by Government of India since 1 April 2008 had head a provision of 5% of the total budget of a project for capacity building. The earmarked budget is only sufficient to train members of watershed-development team, watershed committee and GS and is insufficient for training of higher level stakeholders. Therefore, state-level training institutes.

PROSPECTS

The watershed-development programme of India has been evolving since its birth after the Independence of the country. The policies and guidelines for making the programme effective and sustainable are being regularly upgraded by the Government of India to match the problems being encountered by different stakeholders ranging from the primary stakeholders, mainly the watershed communities, to the State Level Nodal Agencies as well as the Central Ministries. The Government is investing heavily in the concept, because despite the earlier-stated problems, it has the potential to accomplish high agricultural growth, meet the food security targets, attain high level of rural development and boost the Indian economy while maintaining the functionality of the natural resources.

Augment water conservation and harvesting for productivity

It is estimated that by 2050, about 22% of the total geographic area and 17% of the population will face water scarcity. Water scarcity is the outcome of the ever-growing population, which results in higher demand for water in agriculture, industrial and domestic sectors. Consequently, share of agriculture sector in total water use may reduce from 78% at present to 68% in 2050 due to competing demands from other sectors. Groundwater, which is the major source of irrigation at present, is rapidly declining by about 1 m annually in the rice–wheat areas due to overexploitation. Therefore, goals of enhanced food production and agricultural growth will have to be accomplished from declining availability of water, thus necessitating its efficient and optimal utilization. However, water availability, especially for agricultural purpose, can be substantially increased through watershed-development programme as water harvesting is an integral part of the programme; other activities of the watershed-development programme can be undertaken without watershed programme but not water harvesting. There is a potential to harvest about 24 million ha-m of rainwater through small-scale water-harvesting structures in different rainfall zones of India, of which, about one-fourth can be harvested in zones receiving rainfall < 1,000 mm/year. With this, an additional food grain production of about 60-65 million tonnes can be easily realized, along with multitude of physical to social benefits like enhancing crop productivity, food supply and income, increasing water and fodder for livestock, increasing rainfall infiltration, thus recharging shallow groundwater sources and base flow in rivers, reducing flood incidence, reducing soil erosion and sedimentation, and bridging water supply during droughts and dry spells alongwith *in-situ* water conservation.

Realize potential of rainfed agriculture

Under scenario of declining trend in net sown area, which is well below the prescribed threshold limit of 2.0 ha of rainfed land or 1.0 ha of irrigated land required for a family of 5 to 6 members, and stagnant agricultural productivity, ensuring of food security will be a difficult challenge to face in the future. The average productivity of all food grain needs to be doubled from the current 1.8 t/ha to 3.4 t/ha to produce the estimated 450 million tonnes of food production from net sown area of 140 ± 2 million ha by 2,050. In the light of limited scope of increasing production from the irrigated sector, transforming rainfed farming into more sustainable and productive system through efficient use of natural resources provides the only viable alternative to the problem. India ranks first among the countries that practice rainfed agriculture both in terms of extent and value of produce from it. Out of an estimated 140.3 million ha net cultivated area, 79.44 million ha (57%) is rainfed, contributing only 44% to the total food grain production. It is estimated that even after achieving the full irrigation potential, around 40% of net cultivable area of 142 million ha will still remain rainfed. Rainfed agriculture supports nearly 40% of India's estimated population of 1,210 million in 2011. Cutting-edge and socially acceptable conservation and production technologies implemented through integrated participatory watershed-development approach, well supported by appropriate and forward-looking agricultural policies for promoting all-round development of agriculture sector with a focus on water conservation and soil health.

ALTERNATIVE STRATEGIES

Prioritization of critical areas for erosion control in watersheds

Earlier studies carried out in RVP catchments have established that by treating a fraction of the critically eroded area of a watershed, the soil loss can be reduced drastically. This needs to be further strengthened by more detailed studies in different agro-climatic situations and toposequences. Prioritization of critically eroded areas needs to be done to reduce the cost of treating a watershed in terms of capital and time.

Assessment of water availability and water quality at different watershed scales

A systematic approach with the help of modern tools, such as GIS and Remote Sensing, and procedures (watershed-scale hydrological models) is needed to critically assess water availability and quality in watersheds at micro and macro scales in different agro-climatic regions of the country. Assessment of water availability will help in its better planning and utilization.

Identification, evaluation and refinement of water harvesting techniques in different regions

Water harvesting is location specific and depends on hydrogeology, agro-climatic conditions and other watershed parameters of the area. Therefore, identification and evaluation/revival of indigenous/non-conventional water-harvesting techniques is needed for further refinement, wherever feasible, to make rainwater harvesting suited to local conditions for easy adoption by the watershed communities.

Strategies for augmentation of groundwater recharge, its quantification and management

Over-exploitation of groundwater resources and a general decline in water table has given an impetus to groundwater-recharge techniques as well as the quantification of recharge affected by these techniques. Along with conventional methods of augmenting ground-water recharge, other several recharge techniques like recharge pits and shafts, injection wells, etc. need to be refined for improving the impact of these water-harvesting structures on ground-water recharge and their popularization in watershed programmes.

Quantification and valuation of intangible benefits and environmental externalities of watershed management programmes

Natural resource management (NRM) projects yield a variety of intangible benefits, which have long-lasting effects and impacts. Most of the evaluation studies hardly quantify them in physical terms. Efforts are required to develop ways and means for quantification and valuation of intangible benefits that are realized from NRM technologies and watershed-development projects. Optimum utilization of available water resources in the watershed conveniently have been budgeting including rainfall, runoff and any other source of water in the watershed but ignoring the available waste water in the watershed. It is high time to considered waste water as one of the water resources for agriculture. Therefore, plan should be made to utilize available waste water with treated/untreated as per its quality.

SUSTAINED GOVERNMENT INITIATIVES MADE INDIA A GLOBAL LEADER IN MICRO IRRIGATION

T. B. S. Rajput*

Abstract: *Indian green revolution in early seventies of the last century made India not only a self sufficient nation in food grains but also enabled it to export to other countries. But soon after realization started that in the interest of maximizing food grain production we have over stressed our natural resources of soil and water. This opened up a new thought process of sustainability of use of natural resources. Increase in efficiency of utilization of natural resources became the favourite topic for researchers, policy makers and other stake holders in early eighties. Diversification of agriculture particularly encouragement to increasing horticultural production to meet the nutritional requirements of the largely vegetarian population in the country came to the focus of the policy makers. Government of India through its different initiatives supported by appropriate need based dynamic policies for promoting horticulture in general and micro irrigation in particular resulted in quantum jump in horticulture production, surpassing the food grain production in the country, during the last year. Government of India followed a multi-pronged strategy for promotion of micro irrigation in the country. It included policy guidelines, offsetting its high initial cost partly by Government funding, developing research base and encouraging industry for production of quality micro irrigation equipments locally. The real cause of success was the dynamism in Government policies to match the need of the time for promoting water saving strategies and simultaneously enhancing production of fruits and vegetables through National Horticulture Mission, Horticulture Board and Mission for Integrated Development of Horticulture. The article presents a detailed firsthand account of the progress of micro irrigation in the country from its inception to the point of India becoming the country with the largest micro irrigated area in the world.*

Introduction

India has limited land and water resources with only 2.3 % land and 4% of water but with a population of over 17 per cent of the World. Immediately after independence in 1947, Government of India started investing rather heavily in increasing its water resources from a mere 22.6 Mha to the present level of over 100 Mha out of a total potential of 140 Mha. Introduction of high yielding varieties of cereals combined with developed water resources and of course with the use of chemical fertilizers brought about a green revolution in the country. Government of India also initiated several National and State level organizations for developing package of practices appropriate for local agro climatic and socio economic situations. All these strategies resulted in quantum jump in food grains production from a mere 52 MT in 1952 to 295 MT in the year 2017. This quantum jump in production for food sufficiency stressed the water resources. To increase the production sustainably 450 MT for 160 crores by 2050, there're is an urgent need to conserve the depleting water resources through policy, people's participation, capacity building, technological advancement and technology transfer pertaining to savings of each and every drop of water.

Agriculture is the major consumer of water (about 80 %) with very poor utilization. Initially very large dams were constructed for storing of water and then linked with large canal network. Timely completion of big irrigation projects was all the time challenging and having several litigations. Irrigation experts then started realizing that instead of creating additional large dams/ irrigation projects which have long gestation periods and are no longer economically viable due to cost escalation (many fold) and low water-use-efficiency (as low as 38%) such projects have. This happened because of greater emphasis only on

*Emeritus Scientist, Water Technology Centre, IARI, New Delhi - 110012

the development of water resources and little/ no emphasis on its efficient utilization. Since surface and underground water resources were made available to the farmers free of charge, these resources were exploited mercilessly. This has been reported by the experts that water would be the single most critical limiting factor for India's economical development requiring continuous promotion of micro irrigation for reducing water consumption in agriculture.

Modern micro irrigation systems have shown rapid growth in the last three decades all over the world and in the past 25 years in India. Countries like USA, Spain, Israel, Australia and Mexico have been promoting by a large extent and Canada, Cyprus, Iran, U.K., Greece and New Zealand to a lesser extent. India also has not been lagging behind in the adoption of drip irrigation and took big leaps in last two decades to become a leader.

Development of Micro irrigation

The concept of drip irrigation goes back at least to the ancient Egyptians who placed porous pots in the soil and filled them with water. Use of subsurface clay pipes for irrigation in Germany led to doubling of crop yields in **1860 and perhaps that was the beginning of the concept of applying irrigation water directly to the root zone.** Nehemiah Clark, in 1873, obtained the first known US patent for a water-emitting device as a dripper (a simple hole).

Modern drip irrigation began its development in Afghanistan in 1866 when researchers began experimenting with irrigation using clay pipe to create combination irrigation and drainage systems. In 1913, E.B. House at Colorado State University succeeded in applying water to the root zone of plants without raising the water table. Perforated pipe was introduced in Germany in the 1920s and in 1934; O.E. Nobey experimented with irrigating through porous canvas hose at Michigan State University.

In the early 1960s, experiments in Israel reported spectacular results when they applied the system developed by Blass in the desert areas of Negev and Arava (Locascio and Smajstrla, 1989). Micro tubing, was the first controllable low flow equipment that Simcha Blass worked with when he introduced the idea of irrigating crops on a field scale at frequencies similar to those in greenhouses. The micro tubing emitters could be adjusted to most types of terrain, compensating through variable lengths and bores for line pressure changes and changes of elevation. For a number of practical reasons, clogging, fragility, and a high labor factor for installation and maintenance, the micro tubing has largely been replaced by compact emitters that embody the principle of the micro-tube, but not its hydraulic adjustability or facility for locating the drip points away from the pipe(Rajput and Patel, 1999). The first successful compact emitter was the spiral tube emitter, which also was designed in Israel.

Zohar (1971) was the first irrigationist to successfully experiment with drip irrigation under field conditions and drip irrigation was first commercially used for glasshouse culture in England (Waterfield, 1973). The interest of scientists and engineers kept increasing in the field of drip irrigation resulting in increasingly larger number of attempts for its improvement and adoption.

In India, the use of drip irrigation can be traced back to the ancient custom of certain parts of India of keeping a *tulsi* plant in the courtyard (Agricultural Engineering Directory, 1998). During the summer months, the plant was irrigated by hanging a pitcher, full of water and with a minute hole at the bottom to allow trickling of water. A technology similar to today's drip irrigation was originally practiced using bamboo pipes in Meghalaya, perforated clay pipes and pitchers in Maharashtra and Rajasthan. A few tribal farmers of Khasi and Jaintia hills continue to use this 200-year-old system to irrigate the betel leaf or black pepper crops planted in mixed orchards. (Prasad, 1997). The channel sections, made of bamboo, divert and convey water to the plot site where it is distributed without leakage into branches, again made and laid out with different forms of bamboo pipes (Fig 1).

The use of drip irrigation system in its present form started in India in 1970. The work at Water Technology Centres at Indian Agricultural Research Institute, New Delhi and Tamil Nadu Agricultural University, Coimbtore are important among the early references on drip irrigation in India (Michael, 1978 Chakarvarthy et.al, 1998). Regular research work and beginning of adoption of drip irrigation system started in mid seventies (Sivanappan,

Fig. 1 Bamboo drip irrigation in Meghalaya

1998). Efforts to take the drip irrigation system to Indian farmers for commercial cultivation started in real earnest around 1980. In India, the area under drip irrigation had grown exponentially from a negligible level in 1975 to over 10 Mha in the year 2017, with a current target rate of over 1.0 Mha per year. This phenomenal growth of micro irrigation in India is achieved mainly because of the Government of India initiatives in the form of its dynamic policy, encouragement to research and demonstration, strict guidelines for industry and financial support to farmers. Significant developments in micro irrigation technologies and increasing awareness helped in increasing cultivated area under micro irrigation in the country. Important initiatives of the Government of India for promotion of micro irrigation in the country are presented in the following paragraphs (Davis, S. 1974).

Administrative Policies

Use of plastics in agriculture for different purposes put together is commonly termed as plasticulture. In India, the organized efforts in this key sector of plasticulture were initiated way back in 1981 with the constitution of National Committee on the use of Plastics in Agriculture (NCPA) under the Ministry of Petroleum, Chemicals and Fertilizers. Its task was to promote and develop the use of plastics in agriculture, water management and related fields. National Committee on use of Plastics in agriculture has played a crucial role in overall plasticulture promotion in the country. The Plasticulture Development Centers (PDCs) set up by it in major agricultural universities played an important role in plasticulture research, demonstration and taking the proven technologies to farmers fields through their training programmes and extension activities.

Govt. of India acknowledged the importance of these plasticulture applications in 1991 and announced subsidy scheme in a few selected states. Encouraged by the response of farmers, Govt. of India announced a massive subsidy scheme of 250 crores during VIII plan (1992-1997). During IXth plan, plasticulture application got a further thrust with an outlay of Rs. 375 crores i.e. 50% higher than VIII plan. Up to year 2000-2001, an area of 2,85,000 ha was brought under drip. Considering the importance of plasticulture in horticulture in particular, GOI reconstituted and renamed NCPA as NCPAH (National Committee on Plasticulture Applications in Horticulture) in May 2001 with the Hon'able Minister of Agriculture and Farmers Welfare as its chairman. Different Plasticulture Development Centres created in the country were also rechristened as Precision Farming Development Centre (PFDC) with a focus on optimization of available natural resources with the help of different plasticulture interventions in agriculture/ horticulture (Fig 2).

National Committee on Plasticulture Applications in Horticulture was given specific mandate of planning, operation and monitoring of schemes related to all plasticulture technologies, such as polyhouses, net house, low tunnels, drip irrigation, sprinkler irrigation and plastic mulching, etc., as well as their monitoring and evaluation. The committee was also made responsible for overseeing the working of twenty two Precision Farming Development Centres in the country for research in the field of water saving and yield enhancement in horticulture through various plasticulture applications. Considering the high cost of plasticulture applications, on the recommendation of NCPAH, the Government of India had started providing subsidy to farmers for different plasticulture applications in water management (drip and sprinkler), greenhouse technology, plastics mulching and other plasticulture applications.

Government of India issued guidelines for implementation of microirrigation schemes across the country laying down strict conditions for eligibility for the beneficiaries and system suppliers. Guidelines also charted out the responsibilities of all stake holders including scheme implementing

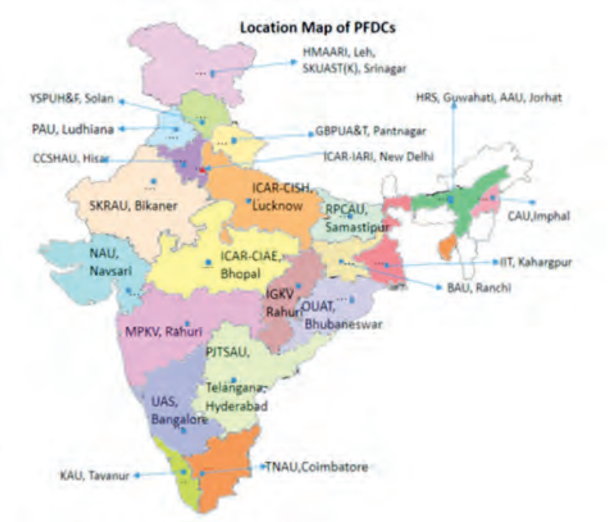

Fig 2. Precision Farming Development Centres, (Sponsored by NCPAH, Ministry of Agriculture and Farmers Welfare, GoI)

State Government officials. Guidelines laid out unambiguous criteria for crop wise Central Government assistance to farmers. Agriculture being the State subject, the guidelines provide for enhanced assistance to the farmers using State funds along with Central assistance. Several State Governments have enhanced their share significantly to help the farmers in adopting micro irrigation technology for efficient use of water and fertilizers and to improve crop yields.

Government constituted a National Task Force on Micro irrigation in the year 2004 to estimate the extent of cultivated area that can be brought under microirrigation and also to suggest ways and means to achive this target in a time bound manner. The task force estimated that up to 69 Mha area could be brought under micro irrigation in the country (Table 1). It also suggested ways and means for enhancing area coverage under micro irrigation further in a time bound manner. On the recommendation of the National Task Force a National Mission on Horticulture was launched in the year 2005 with a clear aim of enhancing horticulture production in the country. These efforts got further boost by another initiative of the Government in the form of constituting a National Mission on Micro Irrigation (NMMI) in the year 2006. The scope of these missions was enlarged to bring in non horticultural crops too by declaring a Mission on Sustainable Agriculture (NMSA) in the year 2010. Then integrating everything, Government declared Mission for Integrated Development of Horticulture (MIDH) in the year (2014). Through all these missions the Government encouraged promotion of horticulture production in the country besides optimizing the use of limited land and water resources in the country.

Table. 1. Potential of Drip Irrigation in India

Crops	Area, million ha	Area suitable for micro-irrigation, ha
Cereals and Millets	100.4	00.00
Pulses	22.50	00.00
Sugarcane	4.10	4.10
Condiments & Spices	2.19	1.40
Fruits	3.40	3.40
Vegetables	5.30	5.30
Coconut	1.90	1.90
Oilseed	26.20	1.90
Cotton	9.00	9.00
Others	1.40	00.00
Total	176.39	27.00

The exemplary progress in horticulture in India is well related to the growth of micro irrigation as it was basically meant for horticulture. But the recent reports from Precision Farming Development Centres, Agricultural Universities about the positive impacts of micro irrigation on almost all crops the Government has now mandated to include non horticultural crops too under the micro irrigation scheme.

Socio economic Policies

In India, land holdings are very small (more than 80% land holdings are less than 2 ha) and the farmers are resource poor. Micro irrigation is the most efficient method of irrigation but is expensive too. It was understood that small and marginal farmers in India will not be able to benefit from microirrigation technology owing to its high initial cost. .The unit cost of drip irrigation system varies with respect to plant spacing. Moreover, the cost of the drip system varies from state to state depending upon the existing demand and marketing network. Government after analysing the situation decided to offset the high initial cost of micro irrigation equipment through a subsidy scheme for small and marginal farmers (with land holdings up to 5 ha). To address the problem of very poor and very small farmers provision of additional subsidy was kept in the scheme. The scheme also addressed the issue of regional inequity in agricultural development by keeping different levels of subsidies for different regions.

The assistance under the "Centrally sponsored scheme on development of horticulture through plasticulture interventions" was made available for all types of drip / micro irrigation systems such as on line drip irrigation systems, in line systems, subsurface drip irrigation systems, microtube, microjets, fan-jets, micro sprinkler, mini sprinklers, misters and similar other low discharge irrigation systems. The assistance covered all farmers growing horticultural crops like fruits, vegetables including potato, onion and other root and tuber crops, spices, medicinal and aromatic plants. Only new installations i.e. invoiced and installed on or after April 1, 2000 were eligible for assistance. Farmers who had installed drip irrigation systems prior to this date without availing the subsidy under the centrally sponsored scheme were eligible for assistance for the additional area covered under drip irrigation after April 1, 2000. The assistance was extended to farmers cooperatives and each member is considered as beneficiary. The assistance was provided for a maximum area of 5.0 ha per beneficiary family in whose name the land belongs. A farmer was considered eligible for assistance only if adequate water is available for the area proposed to be brought under drip irrigation i.e. 1.0 lps per ha for 4 hrs per day for orchard crops and 3 lps per ha for 4 hrs per day for vegetable crops.

The nationalized banks give loan on a simple interest of 10 per cent per annum only, under a scheme of National Bank of Agriculture and Rural Development (NABARD) for promotion of drip irrigation in the country. Currently Government of India is providing up to 40 per cent financial support to farmers to meet the cost of drip irrigation systems in the country. Besides this financial support of the Central Government, a minimum of 10 per cent of cost of drip system is also available to the farmers from the State Governments. .. Several States have increased their share to help the farmers for adopting drip irrigation in their States.

Industrial Policies

In India, the farmers are conversant with micro irrigation techniques since 1970s. However, micro irrigation systems were initially not popular due to its high initial cost, poor quality of components and lack of services from the system suppliers. It took more than ten years before Indian business started showing interest in the systems, after getting convinced that the system has potential in the country. By the time researches in different ICAR Institutions and Agricultural Universities had provided adequate data to prove that the systems not only saves water but also help in improving crop yields and the quality of the produce. The positive results of the experimentations by the grape growing farmers in Maharashtra proved as catalyst in popularizing micro irrigation in the country.

In the initial stages, i.e. in early eighties, hardly any micro irrigation equipments were manufactured locally and were imported mainly from Israel and USA. With the financial support schemes and other enabling initiatives of the Government the adoption of micro irrigation in the country started increasing. Several micro irrigation equipments suppliers cropped up with mainly imported products but the local manufacturing industry was not growing at the desired pace. The Government started putting stringent conditions on the system suppliers to manufacture at least two main system components, namely lateral pipe and drippers, locally to be eligible to participate in the scheme partly funded by the Government. These stringent conditions forced the irrigation industry to mature in the country quickly and the manufacturing of most of the micro irrigation components started within the country. In fact, India today is net exporter of micro irrigation equipments manufactured in India.

Standardization of Micro irrigation hardware

The Government of India kept a constant vigil on the quality of micro irrigation hardware supplied by private entrepreneurs to the farmers. For this, the Government issued strict guidelines from time to time. Since the beginning of the Centrally sponsored micro irrigation scheme the system suppliers were encouraged to initiate production of micro irrigation systems indigenously .In case they were importing any components then they could do so only for a maximum of two years within which they were asked to initiate its production locally. To keep watch on the quality of micro irrigation systems supplied to the farmers, the system suppliers were advised to supply only ISI marked products. Government also made it mandatory for the micro irrigation system suppliers to train the farmers and maintain the systems at least for three years to avoid failures of the installed microirrigation systems. A provision of Joint Inspection Team as well as third party random checking on farmers fields resorted to by the Government to ensure ISI marked good quality systems reaching the farmers.

Government established a National Committee in the Bureau of Indian Standards for developing and certifying irrigation equipments manufactured in India for their desired quality. The Committee then started developing National Standards of different micro irrigation components under the banner of Bureau of Indian Standards (BIS) in 1986. The Government made it mandatory that all components of micro irrigation system supplied to the farmers must have BIS mark on it. All the products now carry BIS mark to indicate that the product meets the quality requirements. By now 17 standards for different microirrigation components have been developed. These standards are as stringent as Global standards and that's why Indian industry is able to export micro irrigation equipments to other countries.

Indian standards on different facets of microirrigation systems are formulated by irrigation and Farm Drainage Equipment and System Sectional Committee FAD 17 (erstwhile FAD 54 and FAD 35) of BIS. It has formulated a number of Indian Standards on microirrigation systems. The physical components required to apply water by micro irrigation system include the emitters, lateral lines, manifold lines, main and submain lines, filter, chemical injectors flow control station and other necessary items. Most of the Indian Standards (Table 2) on irrigation equipment are based on corresponding International Standards, which have been adopted after suitable modifications to meet indigenous requirements.

Academic Advancement Strategies

Research efforts for the encouragement of drip irrigation are being promoted by Indian Council of Agricultural Research, State Agricultural Universities, National Committee for the Use of Plastics in Agriculture, and the drip manufacturers. Ministry of Agriculture, Ministry of water Resources and different State governments sponsored promotional activities for drip irrigation. But its application at commercial level was encouraged by the formation

Table 2. Important Standards developed by the Bureau of Indian Standards

Bureau of Indian Standards	
IS 14482 : 1997	Irrigation Equipment - Polyethylene Micro Tubes for Drip Irrigation – Specification
IS 14791 : 2000	Prevention and Treatment of Blockage Problem in Drip Irrigation System - Code of Practice
IS 11624 : 1986	Guidelines for the quality of irrigation water
IS 11711 : 1986	Recommended criteria for adoptability of different irrigation methods
IS 12786 : 1989	Irrigation Equipment - Polyethylene Pipes for Irrigation Laterals – Specification
IS 13062 : 1991	Irrigation Equipment and Systems - Evaluation of Field Irrigation Efficiencies – Guidelines
IS 14178 : 1994	Pressurised irrigation equipment – Terminology
IS 14792 : 2000	Irrigation Equipment - Design, Installation and Operation of Sprinkler Irrigation Systems - Code of Practice
IS 13487 : 1992	Irrigation Equipment - Emitters – Specification
IS 12785 : 1994	Irrigation Equipment - Strainer-type Filters – Specification
IS 14743 : 1999	Irrigation Equipment - Hydrocyclone Filters – Specification
IS 14483 : Part 1 : 1997	Fertilizer and chemical injector system - Part 1 Venturi injector
IS 14141 : Part 1 : 1999	Irrigation Equipment - Sprinkler Pipes - Specification - Part 1 : Polyethylene Pipes

Bureau of Indian Standards	
IS 14141 : Part 2 : 1999	Irrigation Equipment - Sprinkler Pipes - Specification - Part 2 : Quick Coupled Polyethylene Pipes
IS 4985: 1999	PVC pipes for water supply
IS: 4985: 1985	Specification for un-plasticized PVC pipes
IS: 10799: 1984:	Code of practices of design and installation of trickle irrigation
IS 12232: (Part I) 1996	Irrigation equipment rotating sprinkler Part I, Design and Operational requirements (1st revision)
IS 12232: (Part II):1995	Irrigation equipment rotating sprinkler Part II, Test Method for uniformity distributions (1st revision) (amendment I)
IS 14483: (Part I) 1997	Fertilizer and Chemicals Injection system Part I Ventury injection.

of a National Committee on the Use of Plastics in Agriculture. The committee has established 25 Precision Farming Development Centres in different agro climatic conditions of the country for providing research support, problem and location specific solutions and training and technology dissemination agencies for micro irrigation as well as other precision farming issues in the country.

National Committee for Plasticulture Appplications in Horticulture widened the research base by creating a total of 22 Research Centres renamed as Precision Farming Development Centres (PFDC). The PFDC were mandated to develop regionally differentiated and agro ecologically appropriate package of practices for different local crops to be grown utilizing different plasticulture technologies particularly micro irrigation. The package of practices developed by PFDCs helped in optimizing agri inputs mainly water and chemical fertilizers. These Centres also helped in developing skilled man power and became the knowledge centres for providing critical inputs to the industry as well as to the Government for appropriate policies and products to meet specific agro climatic and socio economic requirements. Standardization of drip systems to suit the cropping pattern of different locations was also taken up by these centres. These Centre maintain technology display units and live demonstration sites for the general awareness about the plasticulture technologies and their benefits. These centres impart training to different State Government functionaries and the farmers and also serve as the free consultation points for the stake holders.

Initial studies on different crops under micro irrigation were conducted at the Indian Agricultural Research Institute, New Delhi and Tamil Nadu Agricultural University, Coimbtore, since 1980 and subsequently at a large number of State Agricultural Universities. These universities also contributed in research and dissemination of the knowledge about the plasticulture applications in different parts of the country. Indian Council of Agricultural Research through its coordinated research project schemes on Water Management and Application of Plastics in Agriculture (APA) since 1989 also contributed significantly. With time new products of microirrigation were brought out by the industry. Appropriate application of new products and technologies were studied and new information were generated by the researchers to keep pace with time. General trend of these researches followed the needs of the time commensurate with the development/ adoption of the micro irrigation technologies in the country (Table 3).

Table 3. Priority areas for research during last two decades

Period	Thrust area
1981-1990	Drip v/s other irrigation methods
	Selection of systems components
	Uniformity of water application
1991-2000	Estimation of water requirements
	Fertilizer application through irrigation water
	Minimization of drip cost through crop geometry
	Fertilizer savings through fertigation
2001-2010	Subsurface drip irrigation system
	Drip hydraulics and drip design
	Drip systems for cropping systems
	Fertigation scheduling

Period	Thrust area
2010 - onwards	Simulation and Modeling of nutrients
	Sub surface drip irrigation system
	Software development
	Automation

The current areas of interest to researchers of the said organizations in the field include, improved automated micro irrigation systems, pulsating systems and subsurface drip systems hardware. The future perhaps is for the hybrid irrigation systems i.e. drip system combined with canal as well as tank irrigation systems and for auto nutriments and moisture controlled drip irrigation systems, as proposed under one of the flagship schemes of the Government of India namely. PMKSY (Rajput and Patel, 2003).

Micro irrigation under PMKSY

The microirrigation scheme was launched by Department of Agriculture & Cooperation, Ministry of Agriculture in January 2006 as centrally sponsored scheme on micro irrigation (CSS) in June 2010, it was up scaled to National Mission on sustainable agriculture (NMSA) and implemented as on farm water management (OFWM) during the financial year 2014-15. The current Government has launched a very ambitious irrigation scheme in the country on June 2016 namely, PMKSY (Prime Minister Krishi *Sinchai Yojna*). Under the scheme micro irrigation has been given another thrust by setting the targets as (1) to bring at least 10% canal command areas under micro irrigation particularly in the tail end reaches of canal commands to address the problem of lesser water availability at the tail end of the canal owing to excess withdrawals on head reaches/ inadequate canal supplies, (2) to use the harvested rain water under all watershed projects through micro irrigation and (3) include at least 25% non horticultural crops too under micro irrigation scheme. Several big projects of combining major irrigation systems with micro irrigation network have been taken up by different State Governmnents for the benefit of large number of farmers particularly in the areas which were not having adequate irrigation facilities (Table 4).

Table 4. Important large micro irrigation projects initiated in India

SN	Name of the Project	Location	Area, Ha
1	Sanchore – Integrated micro irrigation project	Sanchore, Rajasthan	1,11,000
2	Ramthal -Marol Integrated Micro Irrigation Project in Karnataka	Marol, Karnataka	24,000
3	Kandi – Integrated solar powered drip irrigation project	Talwara, Punjab	646
4	Cane Agro – Integrated drip irrigation project	Sangli, Maharashtra	791
5	Indira Gandhi Nahar pariyojna – Pressure piped sprinkler irrigation project	Bikaner, Rajasthan	14,586
6	Narmmada Canal – Microirrigation project	Sanchore, Rajasthan	13328
7	Purna and Chandrabhaga – Gravity pipe irrigation project	Achalpur, Maharashtra	7874
8	Shiggon – Sprinkler irrigation project	Shiggon, Karnataka	8052
9	Balh Valley – Composite microirrigation project	Sundernagar, Himachal Paradesh	11961
10	Singtaluru Phase 1 - Commuity automated drip irrigation project	Singatuluru, Karnataka	10080
11	Tarikere - Comunity automated drip irrigation project	Tarikere, Karnataka	13594
12	Uravkonda – community automated drip irrigation project	Uravkonda, Andhra Pradesh	20202

Impacts of micro irrigation promotional policies

Remarkable growth of micro irrigation in India, driven mainly by the initiatives and policies of the Government, made significant social and economic impacts. The most important as per the objective of the scheme was saving in water used for agriculture. On a crude estimate, adoption of micro irrigation in 10 Mha (Table 5) has resulted in a saving of at least 2.0 Mha-m (20000 Billion litres = 20 Trillion litres) of irrigation water. Most/ almost all micro irrigation systems are installed on tube wells and we can appreciate the magnitude of ground water savings in a country where ground water exploitation has exceeded all limits and the successive Governments have been attempting to enhance ground water recharge and minimize further ground water exploitation through its different schemes.

Table 5. Area coverage under microirrigation in India (March, 2017)

SN	State	Drip	Sprinkler	Total
1	Andhra Pradesh	635081	232859	867940
2	Arunachal Pradesh	613	0	613
3	Assam	310	129	439
4	Bihar	10308	132953	143261
5	Chhattisgarh	20399	263857	284256
6	Goa	1104	955	2058
7	Gujrat	716884	757207	1474091
8	Haryana	25874	556079	581953
9	Himachal Pradesh	3618	2534	5152
10	Jharkhand	12113	10565	22678
11	Karnataka	552856	545933	1098789
12	Kerala	22890	7844	30734
13	Maharashtra	1473832	555050	2028881
14	Madhya Praesh	391055	264650	655706
15	Manipur	47	30	77
16	Mizoram	1727	1175	2902
17	Nagaland	200	5005	5205
18	Odisha	20969	87038	108006
19	Punjab	34359	12448	46808
20	Rajasthan	198783	1549953	1748736
21	Sikkim	6044	3042	9086
22	Tamil Nadu	355422	54059	409381
23	Telangana	470946	164819	635765
24	Tripura	100	392	492
25	Uttar Pradesh	20118	50674	70793
26	Uttarakhan	4863	2656	7519
27	West Bengal	604	50576	51180
28	Others	15500	31000	46500
	Total	**4995618**	**5343484**	**10339102**

Reduced ground water pumping to the extent of 20 Trillion litres a year not only helped reduce the ground water exploitation but also saved energy in its pumping. It is estimated that 2072 GWh energy per annum is saved which otherwise would have been used in ground water pumping. It may be noted that most of small pumping units in remote places are operated on diesel. Reduction in the use of diesel for pumping also saved money of the farmers and also resulted in reduced carbon emission.

Continued emphasis of all successive Governments on increasing area coverage under micro irrigation encouraged the local industry and it grew with time. Today all micro irrigation industry is represented by the Irrigation Association of India which boasts of more than 300 members in it. This growth of industry has led to a tough competition within and has resulted in the availability of improved and efficient products at reasonable cost.

Growing micro irrigation industry generated employment not only in their manufacturing facilities but in its dealership network, system installation and maintenance. Government of India through its policy initiative imposed a condition of servicing and maintaining the micro irrigation systems for at least three years after installation. This made the industry to employ more staff for the task. There is still a wide gap between the requirement of service and maintenance personnel and their availability on the ground which opens up possibilities for village youth for taking up the repair and maintenance task on payment basis. The job requires specific skills which can be availed under the Skill India Program of the Government of India.

Conclusion

All the Government initiatives and policies, supported by the local micro irrigation industry and the enterprising attitude of large number of small and marginal farmers in the country have achieved 10 Mha mark in its area overage under micro irrigation. These efforts have brought India at the top amongst other countries in the world in micro irrigation adoption (March 2018). This achievement besides increasing agricultural/ horticultural production in the country, has saved up to 20 Trillion litres of water each year, mostly from underground water sources. Since most irrigation pumps operate on diesel, a huge sum of foreign exchange is also saved besides the reduced carbon emission. The introduction of PMKSY with clear emphasis on micro irrigation will certainly boost its area coverage under micro irrigation progressively, in coming years.

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INTEGRATED WATERSHED MANAGEMENT VIS-A-VIS SOIL AND WATER TURBULENT CONDITIONS

Seyed Hamidreza Sadeghi[a1] and Zeinab Hazbavi[b2]

Global status of soil and water resources

The world presently faces escalation in the amplitude and frequency of dynamic environmental stressors that impressively challenges our ability to arrange for effective policies (Mohtar et al., 2016). Soil and water resources as integral parts of the earth system, are environmental, social and economic goods (Daba et al., 2018). For instance, soil is a living medium between three main activities of biological, chemical and physical that support human life on the earth (Mohtar et al., 2016). As depicted in Figure 1, soil management, is very critical for global water and food security. The Sustainable development goals (SDGs; UN, 2015) are also highlighted the effective role of soil and water that approved by the UN General Assembly in September 2015 and are applicable by all countries in the world in order to achieve the agreed targets by 2030 (Keesstra et al., 2016; Hazbavi et al., 2018).

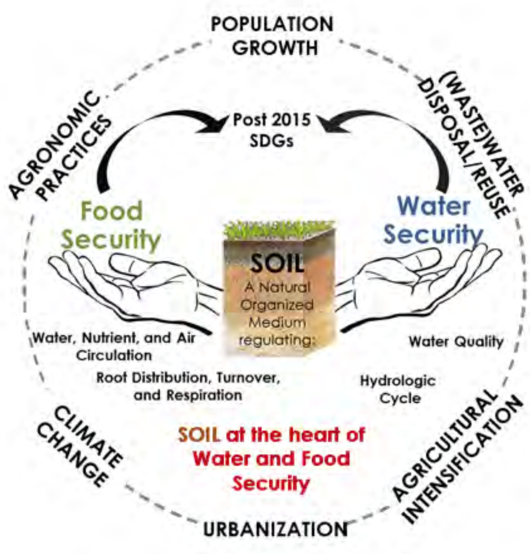

Figure 1. Role of Soil in Global Water and Food Security (Adapted from Mohtar, 2015; 2016)

Unfortunately, soil and water experience several concerns and crises (Flörke et al., 2019; Hazbavi et al., 2019) mainly due to the unsustainable use and management of these valuable resources (Iley, 2003). Demand for soil and water resources with sufficient quantity and quality for different human consumptions will continue to intensify as global populations, urbanization, industrialization, and commercial development increase (Warren Flint, 2006; FAO, 2011; Chanya et al., 2014).

The interaction effect of climate change recently could alter the availability of soil and water resources via floods and drought increasing (Sadeghi and Hazbavi, 2017; Daba et al., 2018). According to reports of the FAO led Global Soil Partnership 20, 75 billion t of soil worldwide are eroded annually from arable lands, which led to a loss of US$ 400 billion, annually (Borrelli et al., 2017). It also reported that more than one-sixth of the world's population does not have access to safe water supplies (Warren Flint, 2006). It is clear that current practices soil and water resources development that have been followed during the last 50 years are far from satisfactorily addressing the challenges of ecosystem sustainability (FAO, 2011). Growing concern about high levels of soil and water loss globally has prompted increasing efforts to improve watershed management. Accomplishing the optimal usage of resources that lead to sustainable outcomes is merely reachable through IWM (Sadoddin et al., 2016; Sadeghi et al., 2017).

Integrated watershed management (IWM)

During the development of watershed management subject, the practices of IWM have now become more conspicuous. The IWM generatesb'' an adaptive, comprehensive, integrated multi-resource management planning

[a1]Department of Watershed Management Engineering, Faculty of Natural Resources, Tarbiat Modares University, Iran; President of the Watershed Management Society of Iran.
[b2] Department of Natural Resources, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Iran; Chair of Student Committee of the Watershed Management Society of Iran.

process that seeks to balance healthy ecological, economic, and cultural/social conditions within a watershed'' (Red Deer River Watershed Alliance, 2015). In Figure 2, key elements of IWM have been shown. An example flow chart to develop the IWM plan has also been drawn in Figure 3.

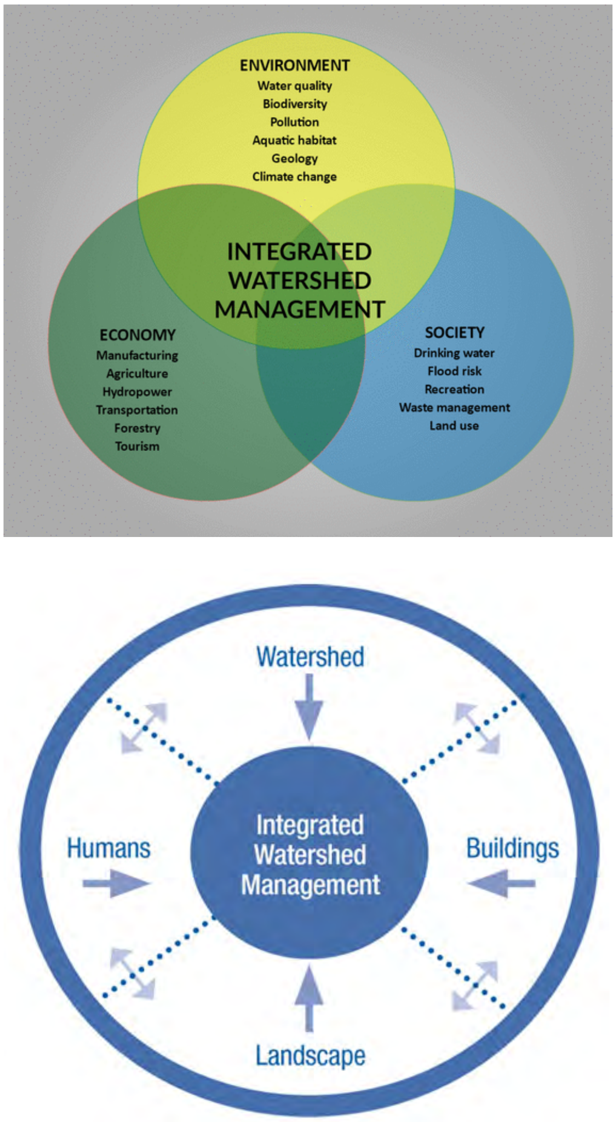

Figure 2. Two general schematic view indicating the Components of Integrated Watershed Management (Left: Conservation Ontario, 2010; Right: https://www.rethinkingwater.ca/rethinking_watersheds.html#top)

To achieve the healthy future of our planet, designing management strategies for global soil and water security are critical. In this vein, sustaining soil and water resources requires a multi-dimensional way of thinking about the connections among natural, social, and economic systems in the use of them to achieve economic vitality while enhancing/preserving ecological integrity, social well-being, and security for all.

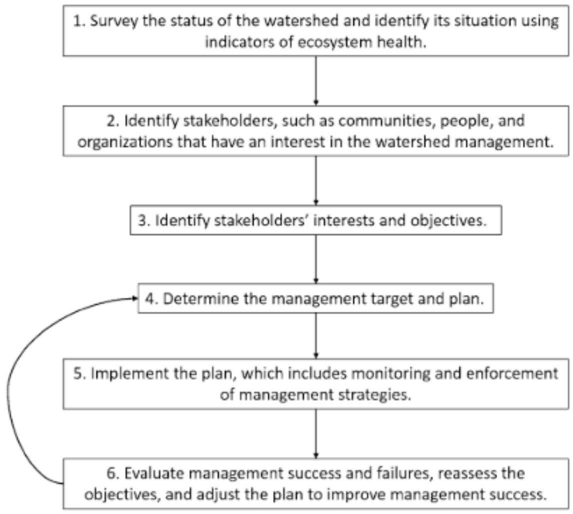

Figure 3. Conceptual model for developing an integrated watershed management plan (Adapted from Wang et al., 2016)

What has become clear is that integrated watershed management (IWM) not only offers a logical and ecologically sustainable way for managing soil and water resources considering both temporal and spatial scales, it is substantially economic, environmentally friend and socially beneficial (Wang et al., 2016; Sadoddin et al., 2016; Sadeghi et al., 2017). In fact, the watershed framework provides a lot of chances and opportunities to streamline the science (Warren Flint, 2006). In its truest sense, the IWM approach by engaging all partners within a watershed, including Federal, State, Tribal and local agencies; these agencies can accompaniment and support each others' activities, avoid reduplication, and leverage resources to achieve greater results (Pravongviengkham et al., 2003; Wang et al., 2016).

Conclusions

Through our evaluation of soil and water resource sustainability, it is indispensable to increase public awareness about the challenges the world is facing in relation to soil and water, as well as amend the manner the soil and water issues is perceived from being a driver of conflict to being a catalyst for collaboration. People have to be convinced to accept responsibility for all of the impressions of their activities, principally if those impressions are irreparable and universal; and if they do not know those consequences in advance, it is their responsibility to learn, to involve in pilot projects and limited experimentations. This is where the idea of IWM intersects with the carrying out of adaptive management strategies. It is a challenging new path for some communities, in part, because it represents a new ethic for many. The outlook for 2050 is encouraging, globally, however much work is needed to achieve sustainable soil and water use and security.

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LAND DEGRADATION UNDER NEW WORLDWIDE EXTENSIVE INDUSTRIAL AGRICULTURAL DEVELOPMENTS: CAUSES AND CONSEQUENCES

Ildefonso Pla[1], Roberto Casas[2], Gustavo Merten[3]

Abstract: The last decades have seen increasing demand and high market prices for food and energy crops, mainly soybeans and palm oil, that have led to drastic and unregulated changes in the use and management of large areas of land, resulting in new and worsening problems of soil and water degradation, including erosion. These changes are mostly happening on savanna and forested lands in tropical and subtropical regions of Asia, Africa and Latin America, under the initiative of large individual producers and corporations, usually seeking short term profit, with little concern for negative environmental or social consequences. Frequently, such cropland developments are justified under an apparent use of so-called "conservation agriculture" systems, mainly based on "no tillage" practices, supposedly leading both to improved production and to soil and water conservation, with decreased erosion and positive effects on the environment and climate change. There is clear evidence, however, that inadequate application of those "conservation agriculture" systems is increasingly degrading the soil and water resources, with negative environmental and socio-economic impacts at local and World-wide level. A new focus is required for research activities that seek solutions to soil and water conservation problems, taking into consideration the complex interactions between land use and changing social and economic conditions, leading to more sustainable policies and decisions about land use and management. Soybean production in Argentina and Brazil is analyzed as case studies.

Keywords: soil erosion, industrial agriculture, land degradation, food production, conservation agriculture

Introduction

The processes of land degradation are closely linked through unfavourable alterations in the hydrological processes determining the soil water balance and the soil water regime, which are conditioned by the climatic conditions and by the land use and management. This will become more important under the previewed effects of global climatic changes, which supposedly will mainly affect hydrological processes in the land surface, mostly related to the field water balance (Pla 2017).

The last decades have seen increasing demand and high market prices for food and energy crops, mainly soybeans and palm oil, that have led to drastic and unregulated changes in the use and management of large areas of land, resulting in new and worsening problems of soil and water degradation. These changes are mostly happening on savanna and forested lands in tropical and subtropical regions of Asia, Africa and Latin America, under the initiative of large individual producers and corporations, usually seeking short term profit, with little concern for negative environmental or social consequences. The importance of those degradation processes increases, if we take into consideration that the new lands incorporated into those industrial agricultural developments are part of the few remaining global land reserves, mostly with high quality soils, for the production of the food requirements of an increasing World population.

It is generally recognized that in a high proportion of lands on steep slopes, the main limitation for its agricultural use are processes of land degradation by water erosion. However, the problems of

[1] [Emeritus Prof. Universitat de Lleida.. Lleida. Spain. President of ISCO. ipla@macs.udl.es]

[2] [Director PROSA-FECIC, Prof. Universidad de Morón. Buenos Aires. Argentina. robertoraulcasas@gmail.com]

[3] [Prof. University of Minnesota –Duluth. USA, Consultant SWC in NT areas South Brazil. mertengh@gmail.com]

accelerated water erosion and other processes of land degradation are not confined to steep slopes, but are also widespread in agricultural areas with more gentle slopes. In general, the increasing trend of land degradation Worldwide is mainly due to the fast growth of the human population and to pressures put on the land by deforestation and over-grazing, and by inappropriate agricultural practices in both subsistence and large-scale high-input commercial agriculture (FAO-ITPS 2015, Pla 1996a).

Although there is clear evidence that large and increasing areas of land are being affected by different processes of soil degradation, most of the existing evaluations of the type, extent and intensity of soil degradation at country or regional level are not very precise or objective. Mass and landslide erosion processes are usually not differentiated from surface erosion problems, leading to an often faulty identification of the origin of erosion processes (Pla 1997, 2011).

In the last 50 years, the land used for extensive agro-industrial developments (mainly for crops like soybeans and palm oil) has increased exponentially in the World, and it is previewed to increase even more in the future, mainly in developing countries of Asia, Africa and Latin América (LA). In LA after some initial soybean agricultural developments on the 1970-80, the land used to grow soybeans increased gradually up to the 1990-2000, when the World demand of soya beans and soya products raised dramatically. The result was a fast growing land area planted with soybeans, that in Argentina went from 6 million ha in 1999 to 20-25 million ha in 2018, and in Brazil from 11 million ha in 1999 to 35-40 million ha in 2018. In the same period new areas were planted with soybeans in Paraguay (3 million ha), Bolivia (2 million ha) and Uruguay (1,3 million ha). Although this large expansion of soybean cropping has brought many economic benefits to the countries and private producers, they are accompanied by great changes in the hydrology, loss of biodiversity and problems of soil and water degradation, including soil erosion in sloping lands, which may affect their medium and long term economic, environmental and social sustainability (Merten and Minella 2013). Soybean agricultural developments in Argentina and Brazil are analyzed as case studies, although the causes and consequences may be extended to other industrial crops and developing regions in the World.

Soil degradation and erosion processes under agro-industrial developments

The initial extensive agricultural developments in Argentina and Brazil (1970-80), in areas previously occupied by pastures, forests or other permanent crops like coffee, included management systems highly mechanized, using excessive plowing for seedbed preparation, weed control etc, which led to problems of soil physical degradation, los of OM, plow pans, erosion, etc (Casas and Albarracin 2015). To control those degradation processes, there was empirically proposed a "no till" (NT) system, as the universal recommended soil conservation practice to control soil erosion and to control anthropogenic climate change through increased C sequestration under any conditions, without due consideration and research on the long-term effects of such management under different combinations of soils, climate, drainage, crops and herbicide use (Pla 2014). Some short term and small scale experiments reporting positive effects of NT systems with different rotations, have not been able to evaluate the effects of the way that system is really applied under field conditions in extensive industrial agricultural developments, and specially the hydrological and long term consequences. Some studies have shown that NT is not as efficient in controlling surface runoff losses as it is in reducing soil loss (Merten et al 2015), and that the absence of soil disturbance leads to surface compaction with consequent porosity reduction (Imbellone and Alvarez 2018). Such contradictory results are probably due to differences between materials from which soils develop, and differences in texture, hydrological and climate regime, the ways in which soil is managed (crops used in rotation, quantity, and quality of crop residues), and other factors. When NT was applied in soils already degraded, with plow-pans, from previous agriculture use and management, it was not been able to reverse the problems of physical degradation for 10-15 years after introducing NT.

Although in the initial stages, at the nineties, of application of the zero tillage system, where crop rotations (soybean-corn, soybean-wheat,..) were regularly used, together with other conservation practices as terracing and contour planting, there were observed some positive effects in soil and water conservation, this situation has been changing, driven by changes in the application of the system derived of political and economical reasons. The last 15-20 years, in the fast expanding new areas under soybeans, derived of the higher profitability of the crop products and the increasing contribution to the export income of the producing countries, the mode of production has become a highly industrialized soybean monoculture, with an intensive use of technology in very large production units. This evolution toward an increasing soybean monoculture, with very poor residue cover and shallow rooting depth, and the abandonment of other conservation practices like contour planting and terracing, which could restrict large machinery traffic (Merten et al, 2015), has derived in increased problems of soil erosion, soil compaction, decrease in soil OM, cumulative negative budgets in soil nutrients (despite increasing use of fertilizers), and environmental problems derived of increasing emissions of greenhouse gases as CO_2 and N_2O.

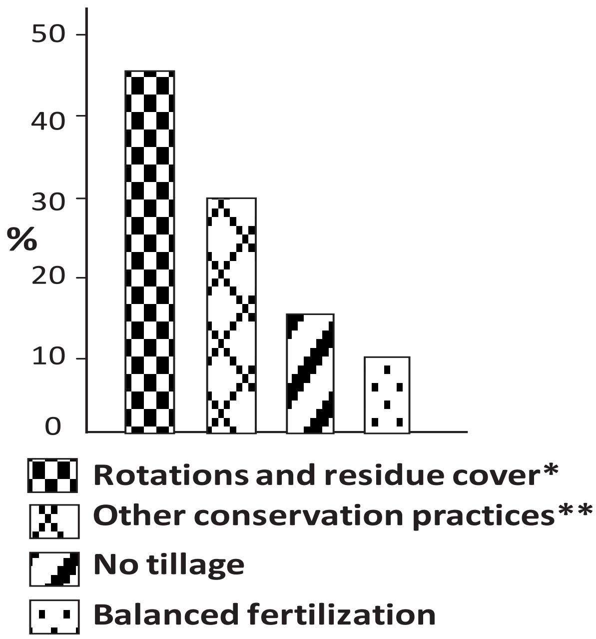

Figure 1: Relative effects of the different components of the "no tillage" soil management system (Intensity and diversity of rotations, residues persistence; ** Terracing, contour planting, strip planting etc)*

Using the proposed relative effects (Figure 1) for the application of the "no tillage system", the more optimistic appreciations consider that only 20-30 % of the cropland under soybeans in Argentina and Brazil would reach an accumulative effect of more than 50%, mainly for failures in the rotations and conservation practices blocks.

Usually, in many official reports, NT is confused with "conservation agriculture" (CA), although at present the other requirements of CA, as rotations, residues cover and conservation practices (Figure 1) are not accomplished (FAO 2001). The proportion of cropland area in LA countries under supposed CA, based on that information reported to FAO, has led to some indirect evaluations and conclusions about an estimated soil erosion reduction of 33% in Argentina, 27% in Paraguay, 20% in Brazil, 20% in Uruguay, and 10% in Bolivia", derived of the application of CT in the large expansion of cropland areas in those countries (Borelli et al 2017). Those conclusions do not coincide, and actually are opposite, with the real field evaluations reported for Argentina (Casas and Albarracin 2015), which probably would also apply for other LA countries like Brazil (Merten et al 2015).

Conclusions

There are clear evidences that the new agro-industrial developments in LA, especially in the very large areas incorporated to mono-cropping of soybeans in the last decades, are leading to various problems of soil and water degradation and derived effects, including soil erosion, affecting the economic, environmental and social sustainability of such developments. The use of NT practices, without appropriate rotations, and with poor soil cover with residues, under soybean monoculture, does not meet most of the requirements of "conservation agriculture". It may be concluded that the adoption of usually considered of universal application, land conservation systems and practices, like cero tillage, without considering the specific conditions (soil, climate, drainage, crops, rotations, etc) may lead, and is leading instead to land, soil and water degradation processes, with onsite and offsite sometimes catastrophic consequences (Pla 1996b, 2011).

The adequate selection of those sustainable practices must be based on research with a broader vision of soil conservation, where all the system components and their interactions are considered and understood with a far-sighted approach, to ensure that short term gains in one aspect or location do not induce long-term losses in other aspects or elsewhere (Pla 2003).

In most LA countries, the application of conservation measures is limited by lack of integration between conservation and development, the lack of legislation or ways to implement it, and the shortage of basic local information, trained personnel and financial resources. There are required programs of sustainable agricultural developments that should not only meet short term economic goals but which would also take into account social interests, environmental preservation (biodiversity and water resources), and maintain national security (provision of hydropower and food) in the medium and long term. To maintain such programs, it would be necessary some incentives and subsidies for farmers to apply the appropriate soil conservation systems, which may require funding based on taxes to the exported agricultural products (Merten and Minella 2013).

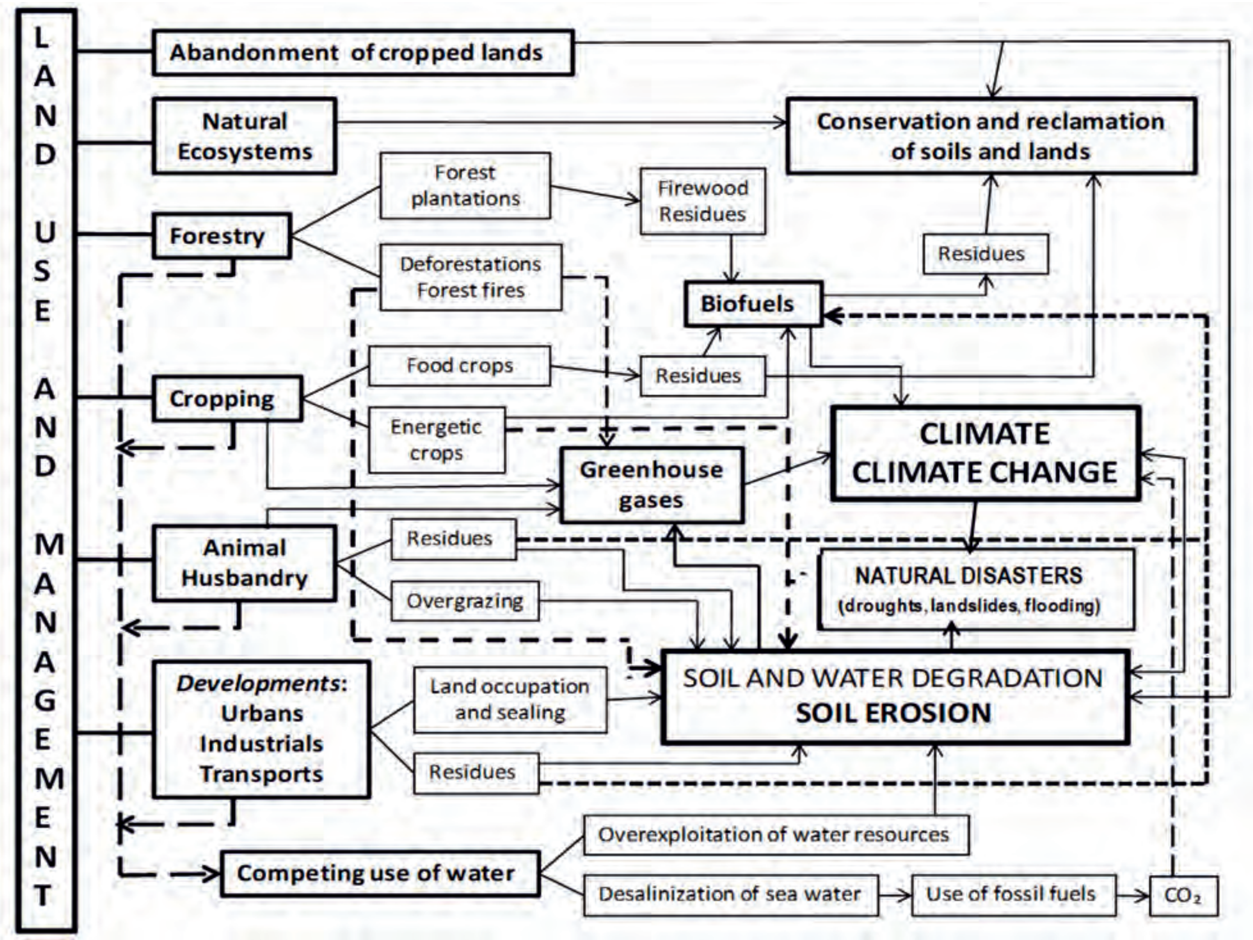

Figure 2: Relations between land use and management, climate, soil and water degradation and soil erosion (Pla, 2014)

In general, the conclusion is that there are required new focus and orientation in the evaluation, research activities and solutions related with soil and water conservation problems (Pla 2003), taking into consideration the complex interactions among different biophysical factors (Figure 2), and the additional changing social and economic conditions, leading to policies and decisions about land use and management in each case.

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SOIL AND WATER RESOURCE CONSERVATION AND MANAGEMENT FOR SUSTAINABLE RURAL LIVELIHOODS IN FOOTHILLS OF NORTHWEST HIMALAYAS, INDIA

Sanjay Arora[1*] and R.D. Gupta[2]

Abstract: Soil and water are the two important natural resources, which are the backbone of the Indian Agriculture. The prime cause for the backwardness of the farmers is reduction in soil fertility and productivity, due to massive soil erosion. Most of the farmers are depending mainly on renewable natural resources for their livelihoods. The inhabitants of the foothill region of Shivaliks have fragmented land holdings and generally resource poor. This poverty is partly caused by inadequate availability of water for crop, livestock and other enterprises. Conservation of soil and water resources on watershed basis, resulted in improving the socio-economic status of the farming community. The article describes some of the successful watershed programmes through farmers' participation, implemented in the foothill region of Shivaliks in Northwest Himalayan tract of India. The soil and water conservation practices adopted by the farmers were the key inputs that resulted in ecological rehabilitation of degraded lands apart from creating awareness and generating income avenues for the rural poor of the region.

Key words: Conservation, Foothills, Shivalik, Watershed, Hill agriculture

Introduction

The Indian Himalayan Region (IHR), with geographical coverage of over 5.3 lakh km^2, constitutes a large proportion of the hotspot and, therefore, contributes greatly to richness and representativeness of its biodiversity components at all levels. Out of this 5.3 lakh km^2, 33.13 million hectares area is being constituted by the North-Western Himalayas. Further, most of the water used to grow maize crop in the sub-humid foothill region of northwest Himalayas, is derived from rainfall. Erratic rains, fragile ecosystems and traditional indigenous management practices are mainly responsible for the current situation. IHR covers 11 states entirely (i.e. Jammu & Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya), and two states partially (i.e. hilly districts of Assam and West Bengal). The region represents nearly 3.8% of total human population of the country and exhibits diversity of ethnic groups which inhabit remote terrains. Further it is reported that the Northwestern Himalayan region (NWHR) which spreads to an approximate area of 33.13 million hectares, comprising of Jammu & Kashmir, Himachal Pradesh, Uttarakhand which is 10.1 percent of country's total geographical area, supports 2.4 and 4 percent of human and cattle population of the country, respectively. This region has a diverse climate, topography, vegetation, ecology and land use pattern. The annual average rainfall varies from 80 mm in Ladakh to over 200 cm in some parts of Himachal Pradesh and Uttarakhand. The major natural resources are water, forests, floral, and faunal biodiversity. Forests constitute the major share in the land use of the region with only 15% of the net sown area and 162% cropping intensity. Due to hill and mountainous topography, the region differs from plain in respect to weather and soil parameters, biodiversity, ethnic diversity, land use systems and socio-economic conditions. Growing concerns for deteriorating environment by stakeholders and others seem to have linkage with gigantic cause-and-effect arguments due to deforestation, landslides, large-scale downstream flooding, increasing poverty and the malnutrition. Recent estimates indicate that NW Indian Himalayas has considerable area under potential erosion rate which is really alarming (Bhatt et al. 2013). In north-

[1]Division of Soil Science and Agricultural Chemistry, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, Faculty of Agriculture, Chatha, Jammu – 180 009(J&K), India; E-mail: aroraicar@yahoo.in, aroraicar@gmail.com *Present address: ICAR-CSSRI, RRS, Lucknow, U.P., India

[2]Ex-Chief Scientist, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu (J&K), India

western Himalayas, on an average, 17% of the area falls in very severe category with erosion rates > 40 t ha^{-1} yr^{-1}, while about 25% area has erosion rate of more than 10 t ha^{-1} yr^{-1}. The states of Uttarakhand in western Himalayas has maximum area of 33%, under very severe category with erosion rates of > 40 t ha^{-1} yr^{-1}. It calls for serious efforts to employ appropriate conservation measures to check land degradation problems (ICAR & NAAS, 2010).

Foothills of Northwest Himalayas

The Shivalik foothills forming part of outer Himalayas in India are spread in the states of Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab and Uttarakhand covering an area of 4,178,000 ha (FAO, 1999). These low hills are considered to be one of the eight most degraded and highly fragile agro-ecosystems of the country. The Shivalik ranges of the North-West Himalayas lies between 28°45′ to 33°37′ N latitude and 73°37′ to 80°19′E longitude (Fig. 1). The climate is sub-tropical to sub-humid and humid with warm summer and cold winter and mean annual rainfall varies from 800 to 1400 mm, 80% of which is received during monsoon months of July through September. Most of the rainstorms received in summer season are of short duration and high intensity whereas those received in winter season are of low intensity and erratic in distribution in the area. All these results in serious problem of soil erosion through rainfall excess in summer monsoon months and soil moisture deficit in the winter months in the region.

Erratic distribution of rainfall, small land holdings, lack of irrigation facilities, heavy biotic pressure on natural forests, inadequate vegetative cover, heavy soil erosion, land slides, declining soil fertility and frequent crop failures resulting in scarcity of food, fodder and fuel, are the characteristic features of this region (Arora, 2006).

The flood waters erode banks, deposit senile sand on fertile land and inundate large areas in the plains disrupting communication and causing colossal loss of human life, livestock and property. Large scale migration of male population in search of work, drudgery of women due to scarcity of drinking water, food and fodder and a general lack of education, are the common socio-economic problems of this region. The benefits of green (cereal production) or white (dairy development) revolution did not reach the foothill farmers because of lack of irrigation facilities, scarcity of arable land and undulating terrain (Sharma and Arora, 2015). This resulted in increasing unemployment, out migration to plains, malnutrition, poor health and enlarged economic disparities and regional imbalances within the states.

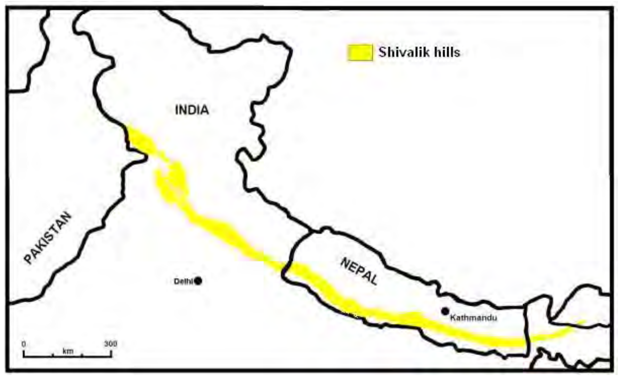

Fig. 1. Foothill region of Shivalik (North-West Himalayas)

Integrated watershed development is recognized as the most appropriate tool for reversing ecological degradation by involving local communities in the process of natural resource base rehabilitation using a host of people-friendly vegetative conservation technologies (Arora 2007). The World Bank has so far aided three watershed development projects in the hills of North India. In 1999, the fourth project called Integrated Watershed Development Project (IWDP Hills) phase II was approved for the Shivalik hills covering all the five Shivalik states. The soil and water conservation was the major objective of all of these projects to enhance agricultural production, generate employment opportunities and improve socio-economic status of the farming community and overall livelihood security in the region.

Agriculture in the Shivalik Foothills

Agriculture still continues to be primarily of subsistence nature due to lack of irrigation facilities. More than 82% of the cultivated area in the Shivaliks is rain-fed or un-irrigated. Undulating topography, deep water table, cultivation on steep slopes, age old agricultural practices and frequent crop failures, due to rain-fed condition, force the people to keep livestock. Grasslands are infested with noxious weeds which have eliminated both fodder as well as commercial grasses.

Although maize-wheat is one of the important crop rotations in the area, other crops grown by the farmers of the foothill region include pearlmillet, sorghum and barley. Pulses like cowpea, pigeon pea, beans, peas, gram, mash, green gram and lentil are cultivated to some extent as sole or intercrops. Among the oilseeds, *Brassica*, sesame, mustard and groundnut are common (Gupta et al., 1990).

Crop yields in the area are quite low compared to rest of the state and country, owing to scarcity of water and low soil fertility. A large number of dry spells of sufficient duration occur to affect yields adversely. Wheat crop being at crown root initiation during these months, water stress proves detrimental to it. Soil fertility of the region is low due to low organic matter content (<0.3 %). The nutrient status is also very poor.

Problems and management approach in foothills and cold arid zone

The problems of small sized and fragmented holdings, difficult terrains, limited accessibility, and prolonged winters also proved dire necessity for following conservation approach for sustainable production of food grains. To meet the demand of increasing population and sustaining the resources for future, conservation approaches like storage of rainwater, conservation tillage, contour bunding, addition of organic matter in the soil, strip cropping, cover cropping, mulching, vegetative barriers, crop diversification, recycling of residues, sloping land management, adoption of improved varieties according to agro-climatic needs and construction and maintenance of water harvesting storage necessary to be adopted by every stake holder (Arora and Bhatt, 2016). There are different resource conservation technologies which help to mitigate the adverse effect of the global warming with a greater stress on the NW parts of the Himalayan region for the judicious use of the natural resources viz. soil and water along with improving the livelihood of the farmers of the region.

The cold arid region of Ladakh has high variability in soil characteristics. Soils of the region are quite distinct from those of other zones due to differences in climate, topography, vegetation and rocks. Because of limited rainfall, dryness and low temperature during most part of the year accompanied with scarce natural vegetation and steep to very topography, and resistant nature of the rocks towards weathering results in the formation of skeletal type of soils with poor profile development. Skeletal type of soils differs widely as compared to soils of other groups formed in sub-tropical, sub-temperate and temperate climatic region. Owing to deficient precipitation, poor vegetative cover and the existence of unfavourable condition to intensive weathering, the fundamental and pedogenic soil forming processes are not very conducive with the exception of valleys or areas having flat and stable topography, highland pastures and Changthang areas where leaching, humification and salinization and/or sodiumisation are sporadically discernible. It has been reported that soils of Ladakh zone are coarse textured, shallow and sandy type which is derived from weathered debris of the rocks. They are subjected to wind erosion and have usually boulders with high permeability and low water holding capacity. Some of the areas stand affected by salinity and sodicity (Gupta and Arora, 2016).

Soil and Water Management Practices

Soil and water conservation measures are aimed at management of rainwater, soil and vegetation resources in a manner that perceptible changes with regard to water resources development take place in the watershed so as to increase land and water productivity on a sustainable basis (Arora et al., 2006). Not only the surface water storage should increase as a result of soil water conservation interventions, but increased ground water recharge should take place. Some of the effective and feasible soil and water conservation practices either indigenously followed or adopted through technological interventions in watershed programmes by the farmers of the Shivalik foothills includes field bunding, pre-monsoon ploughing, terracing, contour trenching, earthing-up in maize, straw and soil mulching and tillage management (Arora et al., 2006; Sharma and Arora, 2008; Arora and Hadda, 2003).

Farmers Perception for Soil and Water Conservation

According to the survey conducted and data of the same presented in table 3, about 89 per cent of the respondents, out of the contacted 120 in each Jammu and Punjab region spread over 15 villages, faced the constraint of non-availability of the agricultural machinery and implements used for rainwater harvesting, as these are costly and the farmers are unable to purchase them (Sharma et al., 2004). The specialized and improved implements were also not available for rainwater management.

Lack of technical knowledge of some improved rainwater management practices is also one of the constraints. About 76.6 and 78.0 per cent of the respondents from Jammu and Punjab foothill region feel that they had lack of skill in handling the practices like contour bunding, staggered trenches etc. About 85-95 per cent of the respondents had problems due to undulating topography and poor economic condition, which causes problem in application of different practices. They had to rely more on human labour rather than machinery because they had sloping and fragmented fields.

Integrated approach to mitigate the adverse effect of the climate change

Soil and water conservation includes conservation farming, storage of rainwater in soil profile, modification of soil profile and addition of organic matter etc. The various soil and water conservation technologies are land levelling, contour bunding, trenching, contour cultivation, strip cropping, cover crops, mixed cropping, conservation tillage, cultivation of fast growing and early maturing crops, recycling of crop residues, use of mulches, vegetative grass barriers, agro-forestry systems, sloping land management etc. (Sharma and Singh, 2013). Among these mulching found to be quite effective but its rate and mode are equally effective (Bhatt and Khera, 2006). Recognizing the importance of these techniques they have great role in conserving natural resources in hill agriculture.

Watershed Management Programme

The increasing anthropogenic pressure on the Himalayan resources to meet the ever-increasing demands for material supplies is leading to their widespread degradation. It was established that ecologically relevant destruction took place in rainfed old croplands within mid-slope and high landscape positions. The continued degradation of the fragile Himalayan region would affect adversely the socio-economic and environmental stability of the region. Major part of the land area of north-western hill region is hilly terrain and considerable part of this is under forest cover. Thus, very small area is available for cultivation and considerable part of it is under rainfed having low productivity. Undulating topography, varied climate, scanty cultivated land, overwhelming percentage of small and marginal holding, difficult conditions, high cost and low returns on food grain crops, poor economic condition of the farmers etc. are main causes responsible for this situation (Gupta and Arora, 2010). Majority of the hill population resides in the ranges of the middle Himalayas having elevation between 600 to 2000 m and is mostly dependent upon rainfed agriculture. Farmers are in a habit of using traditional agricultural techniques and methods for crop production and are getting low productivity almost from all the crops being grown in the region. Therefore, more holistic approach to land use and management is needed to cope with increased pressure on soil resources for sustainable food and fiber production while reducing the adverse off-site environmental impacts of agricultural practices.

Socio-Economic Development

The watershed development programme in agricultural and forest catchments in foothills of Shivaliks aiming soil and water conservation resulted in several ecological benefits viz. reduction in soil loss, development of vegetative cover, fodder production, increase in crop yields, wasteland development, etc. This in turn resulted in the economic development of resource poor rural communities in the region, as indicated below:

Increased availability of fuel, fodder and commercial grass: It was observed that women made a substantial contribution towards rural economy in the Shivaliks. A study by Singh et al. (1996) in the biggest watershed of the project namely Dasuya Langerpur (Punjab) has shown that as many as 86 per cent of the women were engaged in different agricultural operations. In the project, to conserve soil, fuel wood trees and bhabbar grass (*Eulaliopsis binata*) and other fodder species were conserved. Therefore, an increase in the yield of fodder grass or availability of fuel wood would naturally reduce the drudgery of farm women. The increase in the yield of green fodder grasses over the base year varied from 2.8 to 3.5 t $ha^{-1}yr^{-1}$ with the mean of 3.2 t ha^{-1} yr^{-1} in 8 forest watersheds spread over an area of 22,703 ha which generated an additional annual benefit of Rs. 21.88 million at a modest price of Rs. 300 per tonne (1999 prices). Similarly, the increased availability of fuel-wood from trees and bushes varied from 1.7 to 2.2 with an average of 1.9 t ha^{-1} yr^{-1} in those watersheds thereby producing an additional fuel-wood of 43,136 tonnes worth Rs. 25.88 million at the market price of Rs. 600 per tonne. The increase in bhabbar grass (*Eulaliopsis binata*) yield varied from

0.8 to 1.3 with a mean of 1.1 t ha^{-1} yr^{-1}. The value of the additional 15,892 tonnes of air dry bhabbar grass at Rs. 2,000 per tonne was Rs. 31.78 million. The total value of the increased biomass produced from 8 treated watersheds (21.80+25.88+31.78) was Rs. 79.46 million per year. The benefits from timber would, however, be extra.

Employment generation: Bhabbar grass is not only a very effective soil binder, but also provides raw material for paper industry and used for rope making by the rural poor. For paper making, the grass is extracted every year in November-December, transported from forests on camels to yards where it is sun dried and then sent to the paper mills. Grass cutting, transporting and sun-drying provide lean period employment to a large number of local people in the close vicinity of their villages. This job of converting grass into rope provides employment to women, landless and weaker sections of society. Any increase in the availability of bhabbar grass is, therefore, a sure means of additional employment to the poorer strata of the society (Singh, 1997). The tremendous opportunities created by the project for employment generation is evident from the increase in rope making machines. Most of these machines are operated by people from the lowest stratum of society thus giving a boost to the poverty alleviation drive.

The project has generated seven million man days of direct employment to rural poor in the state of Punjab alone. The major share of employment (six million man days) was generated in the forestry component, followed by one million man days by soil and water conservation component.

Economic analysis: One of the changes made in project was the selection of early maturing plantation species and the plantation of a mixture of trees and grasses to ensure early and regular returns. The rationale for adopting these changes is clearly borne out by economic analysis of project activities. Internal rate of return (IRR) for a mixture of trees and grasses (production component) was as high as 17.73 per cent and with applied research there is scope for further improvement as well. The IRR for other important project components (at 1990 constant prices) was found to be 15.79 per cent for soil conservation, 15.50 per cent for milk production, 13.79 per cent for agriculture and 14.0 per cent for traditional afforestation as shown in Table 1.

Table 1. Economic analysis of project components

Component	NPV at 12% Discount Rate (Rs.)	IRR at 12% Discount Rate (%)	Benefit Cost Ratio
Rainfed agriculture (Wheat)	2,53,724	13.79	1.02
Rainfed agriculture (Maize)	2,43,530	13.71	1.02
Milk Yield	21,63,682	15.50	1.16
Soil Conservation	73,941	15.79	1.01
Afforestation (*Acacia catechu*)	19,94,848	14.00	1.18
Afforestation (*Acacia catechu*)	2,23,225	12.97	1.07
Afforestation (Miscellaneous)	73,734	12.34	1.02
Production Component	15,46,578	17.73	1.39
Silvipasture	5,27,623	13.09	1.09
Vegetative Shrub Barriers	63,300	14.45	1.11
Rainfed Horticulture (Mango)	80,498	12.47	1.04

NPV = Net Present Value; IRR = Internal Rate of Return; 1US$≈Rs.70

Productivity and Income Generation through Watershed Programmes

Watershed management programmes will not be self sustainable, if improvement in productivity and generation of additional income does not commensurate with investment. Analysis of time series data in a 370 ha middle Himalayas watershed during 1974-1994 showed that there was remarkable improvement in the average yield of all crops ranging from 2.2 to 7.4 times during the intervention phase (Samra, 2002). The local community continued to invest and sustain productivity till today.

Increased biomass and fodder production resulting from integrated management of watershed at Bunga (Haryana) changed the composition of livestock to more economical animals and reduced seasonal migration of herds due to assured fodder supply during the year.

The harvested rainwater in small storage tanks/ structures/farm ponds can be effectively utilized for supplemental irrigation during lean periods to boost crop production. Evaluation of water harvesting in different agro-ecological regions showed that the productivity of arable lands increased by 4.2 to 15.4 q ha^{-1} with benefit:cost ratio varying from 1.48 to 3.89 (Table 2; Samra, 2002). Water harvesting structures proved to be economically viable, environmentally sound and socially acceptable. The economic analysis of 21 watershed management programmes conducted in different regions showed that investment in these programmes is a profitable proposition from both economic (B:C ratio >1.2) and banking (IRR>17%) point of view (Table 3). Casual employment opportunities @215 man-days/ha/ year during implementation phase and @20 man-days/ha/year in the post-intervention phase were generated (Samra, 2002).

Table 2. Economic analysis of water harvesting structures

Type of structure	Location	Capacity (ha-m)	B:C ratio	Remarks
Unlined pond (natural)	Dehradun (Uttarakhand)	1.65	1.85	Pre-sowing irrigation to wheat
Lined tank	Fakot (Uttarakhand)	-	1.48	Protective irrigation to wheat after terrace improvement
Unlined pond	Sukhomajri (Haryana)	5.5	1.63	Life-saving irrigation to wheat
Unlined pond	Bunga (Haryana)	59.6	3.89	Pre-sowing and flowering stage irrigation to wheat

Table 3. Economic evaluation of watershed management programmes

Watershed	Project span (years)	Discount rate (%)	B:C ratio	IRR (%)
Western Himalayas				
Fakot, Uttarakhand	25	10	1.92	24
Shivalik hills				
Rel majra, Punjab	20	12	1.20	
Sukhomajri, Haryana	25	12	2.06	19
Bunga, Haryana	30	12	2.05	
Joharnpur, Himachal Pradesh	7	10	2.38	28.6

Conclusion

Soil and water conservation practices are essential component of watershed development programme especially in hilly regions. If properly implemented through farmers' participatory approach, the soil and water conservation practices in agricultural catchments, shall enable the farmers to optimize their crop yields and also rehabilitate the erosion prone degraded sloping lands. The crop diversification and cultivation of high yielding varieties shall be possible in the foothills of Shivaliks if the soil and water resources are properly and effectively managed. Also, the fodder requirements livestock can be locally met. The employment opportunities shall be generated and migration of human population shall be restricted, if they get good returns from their lands which is possible through management of limited resources judiciously. The success obtained from adoption of improved practices will enable to change the attitude of tradition bound farmers. The overall development and socio-economic upliftment of Shivalik region is evident from adoption of feasible, easy and effective soil and water conservation measures on watershed basis. The success obtained through watershed programmes will also give strength to planners and decision makers to replicate similar soil and water conservation works in other similar areas.

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STRATEGIES, LESSONS AND EXPERIENCES ON THE SUSTAINABLE SOIL MANAGEMENT

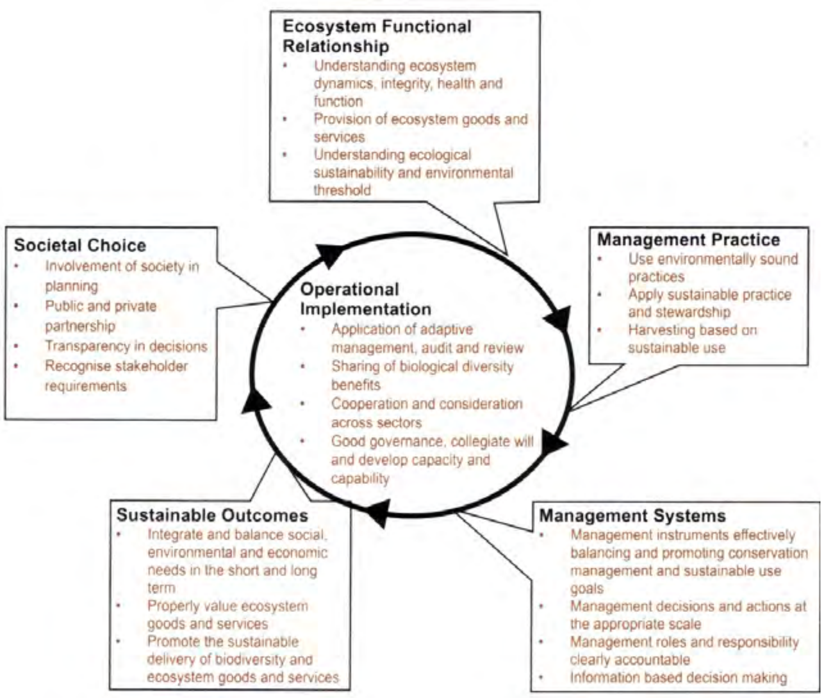
Miodrag D. Zlatic*

Abstract: Land degradation is the global problem from the beginning of mankind. The loss and degradation of land resources need to be seen in the context of policy, socio-economic conditions and the environment. The impact on agriculture, forestry and food production, as well as on the ecological and protective functions of natural and managed ecosystems is universally recognised. To meet these challenges, new and innovative approaches are required. This includes close cooperation with governments, civil society and international and national organisations to ensure a broadly acceptable and efficient implementation, as well as the necessary additional financial, institutional and human resource support. Sustainable management of land resources implies the application of participation methods (Zlatić, 2002; Zlatić, Vukelić, 2002), including the world methods such as: The Ecosystem Approach (Hurni, 1985), CBNRM (Community Based Natural Resources Management), WOCAT (World Overview of Conservation Approaches and Technologies), DPSIR Approach. In this respect paper takes into account description some of the mentioned methods with some examples and lessons learned.

STRATEGIES AND INTENDED ACTION

Ecosystem approach for land use management and soil conservation

"An ecosystem is a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. An ecosystem can refer to any functioning unit at any scale: it could be a grain of soil, a forest, a biome or the entire biosphere. The Ecosystem Approach relates to relevant levels of biological organization, which encompass the essential structure, processes, functions and interactions among organisms and their environments. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems" (UNEP, 2004). The ecosystem approach requires holistic adaptive management to deal with the complex and dynamic nature of ecosystems and the complete knowledge or understanding of their functioning. It can integrate other management and conservation approaches and other methodologies to deal with complex situations. There is no single way to implement the ecosystem approach, as it depends on local, provincial, national, regional or global conditions. A summary of the elements and rationale of the Ecosystem Approach contains the elements presented in graphic 4, however it is not limited to them. The operational implementation of the ecosystem approach foresees the implementation of all principles of the ecosystem approach together. The application of it should be adapted to specific situations and frame conditions. (Graphic 1).



Graphic 1: Ecosystem Approach (Source: CBD 2003)

* Faculty of Forestry, Belgrade University, Kneza Višeslava 1, 11030 Belgrade, Serbia.

Sustainable management of land resources – Prevention of torrential floods and erosion processes

Flash flood prevention includes an integrated system of basins containing technical, biological and control components (Zlatić, 2007; Hurni *et al.*, 2002). Sustainable management of land resources implies the application of participation methods (Zlatić, 2002; Zlatić, Vukelić, 2002), including the world famous methods, such as the ecosystem approach (Hurni, 1985), DPSIR, CBNRM (Community Based Natural Resources Management) and after that WOCAT (World Overview of Conservation Approaches and Technologies). This paper will present the CBNRM method as well as a model of sustainable management of land resources adapted to the conditions of hilly-mountainous areas of Serbia (Zlatić, 1994).

Community Based Natural Resources Management (CBNRM)

CBNRM is management of natural resources based on a detailed plan developed and agreed by all stakeholders (True *et al.*, 2007). The approach at the local community level, so that communities that manage resources have legal laws, local institutions, and economic incentives to take responsibility for a substantial sustainable use of these resources. According to this plan of natural resources management, the community becomes the primary implementer, with the assistance and under the supervision of professional services.

GOALS OF CBNRM

1. Ensuring voluntary participation of communities in a flexible program that includes long-term solutions to the problems arising from the use of natural resources,
2. Introduce natural resources to wild new system of group ownership and territorial rights of communities that lives in the target areas. The management of these resources should be placed under the custody and control of the resident people,
3. Ensuring appropriate institutions under which the resources are legitimately operated and exploited by the local population to their direct benefit. These advantages can be in the form of income, employment and production of wild animals,
4. The provision of technical and financial assistance to communities that join the program, which will allow them to achieve their goals.

CBNRM can be considered a strategy of management with a precise aim:

1) poverty reduction,
2) conservation of natural resources and
3) promotion of proper management and decentralization.

Poverty reduction is closely linked to the protection of natural resources, because the existence of poor people in developing countries, as well as in Serbia, depends on natural resources. In this respect, it is important to ensure sustainable management of these resources. Decentralization is an important and effective tool in the above management for the following reasons:

- the local population will more precisely identify their environmental problems and prioritize among them, rather than a centralized organization,
- resource allocation is more efficient and transaction costs are lower when decisions are made at the local level, so that government expenditure can be reduced, while resource conservation improves,
- local groups will have more respect for the decisions in which they have taken part,
- monitoring of the use of resources can be improved and
- marginalized groups are gaining greater impact on the local policy

Example of CBNRM in Serbia – The Grdelicka Gorge 2000 programme

The Grdelička Gorge 2000 program represents public participation in the sustainable management of land resources in this part of the South Morava basin (Zlatić, 2001). As a result of natural conditions and inadequate land management, this area was one of the areas that were the most endangered by erosion processes in Europe. The consequences of erosion led the population into misery and migration. Today, in the villages of this hilly-mountainous area, elderly households are the majority. They are neglected with a worrying tendency of being extinguished. The interest of this program is the activation of adequate plant production, which will, with the application of counter-measures, reduce land losses to within tolerable limits and thus protect this area from floods. The project included activities whose goal was to carry out sustainable land management with public participation in decision making, that is, the participation of the local population, production organizations and representatives of the government. This was achieved through direct talks, advisory assistance, and performances in media, surveys, and panel discussions. In this way, the level of awarenesswas raised in the case of all representatives of the public in decision-making regarding the sustainable use of natural resources.

The product of this project is the decision of target groups representing the public of the selected village Grdelica to organize a conservation vineyard-fruit production at the locality of Grdelički Rid. The population of this village and the Agricultural Cooperative ''Grdelica'' decided on certain obligationswith consensus. Responsibilities pertaining to the population include the provision of a production area without the loss of ownership, regular hoeing, harvesting and sales of products to the cooperative, while the cooperative should perform field preparation, terrace making, procurement of planting material, intercropping, protection, preservation and a guarantee of purchase.

The decisions were preceded by a poll and media coverage (Novosti, Politika, TVLeskovac News). The Regional Chamber of Commerce of Leskovac provided some financial support and organized a panel discussion, attended by the representatives of PE "Srbijavode", the Cooperative Association of the Leskovac region, the Agricultural Cooperative ''Grdelica'', the Grdelica Local Community, and the representatives of the Faculty of Forestry and NGO "CEKOR". The importance of this project was emphasized at a panel discussion, not in terms of protection of the environment and land resources, but also for the survival and stay of man in this region. As already mentioned, the project was accepted by consensus, which marked the significance of public participation in decision-making on the sustainable management of natural resources, and thus protection against floods (Graph. 2.).

Graph. 2. An overview of functioning of the "Grdelička gorge 2000" project (Zlatić, 2001)

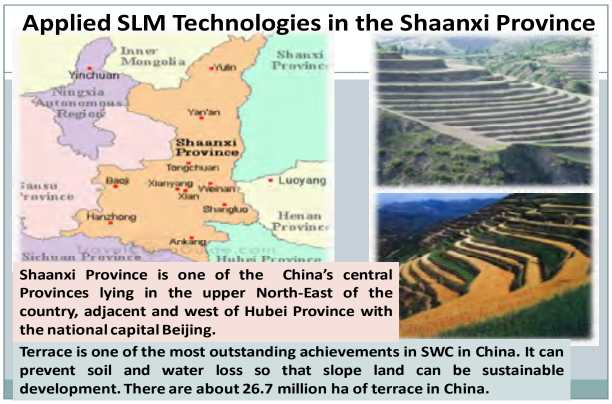
World Overview of Conservation Approaches and Technologies - WOCAT

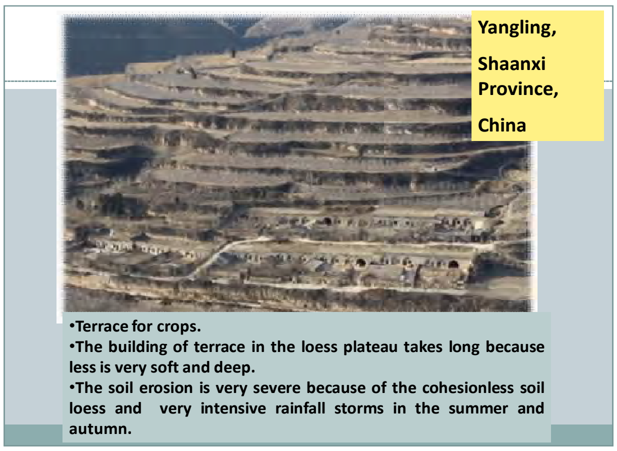
WOCAT programme provides tools that allow SWC specialists to share their valuable knowledge in soil and water management, assist them in their search for appropriate SWC technologies and approaches, and support them in making decisions in the field and at the planning level. It is presented through the world examples as well as from Serbia through the cooperative venture involving the Porečje Company and local farmers in the Porečje region. The lesson learned in this example is how farmers and enterprises can cooperate through joint venture in mutual investments and production, taking care about the conservation of natural resources and environmental protection. The cooperation is a lower burdening for both the enterprise and the farmer, because they share the financial resources for inputs, which facilitates the organisation of production lines.

Example of WOCAT analyse

Serbian contribution to the WOCAT: Cooperation between people and Porečje Company in the region of the Mt. Kukavica.

Regarding great migrations from mountaionous areas, it is beyond any doubt that further development of these regions should be based upon people remaining and surviving in them. Sustainable land use can make this possible as illustrated by the





Photos 1 and 2: WOCAT examles from China

Photo 3:Torrent control from Bolivia

Photo 4: Conservation technologies from Bolivia

example of the cooperative venture involving the Porečje Company and local farmers in the Porečje region (Zlatić, Vukelić, 2002).

Technology used

The land at the altitude of about 600m which had not been cultivated for a long time, small plots which had not been adequately used because no machinery could be implemented, were grouped and rearranged into fruit plantations on terraces. From the aspect of soil and water conservation, the steep slopes of Mt. Kukavica were converted into orchard terraces. These are series of level or nearly level bench terraces, supported by steep risers. The risers are made of earth protected with grass banks. The terraces were made by machines. Orchards were seeded in one row on terrace. This is an evident combination of structural and vegetative measures (Photo 5).

Photo 5. Conversion of unused and erosion-prone land into productive cherry and other orchards (Photo courtesy of Porečje Company)

Cooperation between people and institution

In fruit growing and in the organisation of orchard establishment, organisation form of this co-operation can be defined as an Association of private farmers and the firm "Porečje". It can be explained as follows:

- The territory on which structural, vegetation and agricultural measures were performed is private property of the farmers. Individual farmers offered their land to the enterprise and asked for the land at new localities. Individuals entered joint venture, leasing their land to the enterprise, with the interest from the partnership.
- The co-operation is based on the percentage

from the contracted business both for the farmers and for the enterprise; simultaneously it also performs the jobs, which are not related either to the farmers or to the firm (purchase of mushrooms, medicinal plants). Everything is evaluated by money, and the difference in the relation benefit-cost is paid to the producer.

- Based on incentives, the cooperation contracts the farmers' business activities with the enterprise: purchase of seeds, fertilisers, oil, pesticides, nursery stock, seedlings for fruit plantations and vegetable growing and consulting services.
- The enterprise "Porecje", in addition to the construction of terraces and the incentive to farmers, provides the purchase and sale of end products, as well as short-term credits.

Effects and results

The interest both of the firm "Porecje" and of the farmers in this cooperation is mutual, because the land is converted to organised agricultural production. Plantation orchards are established on previously inadequately used land. Expenses for terracing and plantations are distributed over the entire period of exploitation. The costs of terracing and establishing the first orchards have been payed off.

This cooperation enables the farmer and the enterprise to realise the benefit cost ratio amounting to 1.15 to 1.20. The annual crop of the plantations amounts to some 100 thousand tons of quality fruits: sour cherries, cherries, plums, peaches, apples, pears, raspberries, strawberries. Sour cherry is the most prominent in this type of fruits, especially the variety "Oblačinska". There is a developed and rich programme of the production of frozen fruits, fruit products and especially brandy (Williams Pear Brandy, Apricot Brandy, "Kirsch" Sour Cherry Brandy, Plum Brandy). About 80% of the products were exported to the world market. In the period before economic sanctions, the value of annual production was US$ 35 million.

Advantages of this approach

- Good relationship between individual producers and the firm
- Agreement of demands and necessities of individual producers and the enterprise.
- Good organisational flow of the demands for basic production factors
- Purchase of raw materials and safe marketing of end products.

Disadvantages

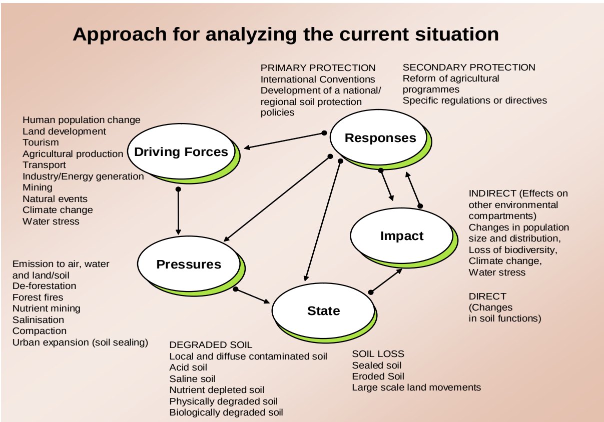
- Insufficient integration of services (mechanisation).
- Insufficient information on leasing the land for joint venture, and not for transfer of property. This means that the land was not sold, it is still owned by the farmers.

Lesssons learned

The lesson learned in this example is how farmers and enterprises can cooperate through joint venture in mutual investments and production, taking care about the conservation of natural resources and environmental protection. The cooperation is a lower burdening for both the enterprise and the farmer, because they share the financial resources for inputs, which facilitates the organisation of production lines. Farmers have short-term credits and reliable customer. The interest of the firm in the cooperation is based on the stable provision of raw materials for the processing capacities of the enterprise, which can not be covered by the firm's own crop production.

DPSIR Approach

In order to bridge between theoretical knowledge and implementation of operational tools in SWC, the use of DPSIR approach is proposed (EU Soil Information, Blum, 2007) (Graphic 3). This distinguishes between Driving Forces (D), which develop Pressures (P), resulting in a State (S), which creates Impacts (I) and for which Responses are needed. A Driving Force (D) can be a demand for more space for industrial production, accommodation, transport facilities, sports and recreation facilities, dumoing of refuse and others. The pressure P, deriving from this demand, is urbanization in a broad sense, which means the construction of new industrial premises, houses and transport infrastructure. The State (S) created through this pressure is sealed soils which means considerable losses of agricultural and forest land. The direct Impact (I) causes less agricultural land and forest biomass production, less rainwater infiltration, less biodiversity and problems with contamination, compaction, decline in soil biodiversity, decline in soil organic matter, salinization, erosion and floods and landslides. An indirect impact might be that farmers have to stop farming as there is no longer land available for agricultural and forest production. Moreover, these farmers might move into other areas causing social and economic problems there.



Graphic 3: The DPSIR approach applied to soil

Source: EU Soil Information, Blum 2007

The responses (R) should be directed at the driving forces (D) through satisfying the demand for new urban structures by means other than sealing new land (e.g. by recycling brown fields, i. e. former industrial sites). Responses (R) can include social and economic measures, incentives or legal institutions in order to reduce urban sprawl. Based on this approach new concept for research were developed (Blum *et al.*, 2004, van Camp *et al.*, 2004).

Table 1 identifies the main research goals, the research clasters needed to reach this goals and the scientific disciplines that must be involved (Blum *et al.*, 2004). The five research clasters are shown in more details in Graph. 8, from which it becomes clear that it is first necessary: to analyse the process related to the eight treats to the soil and their inter-dependency; to develop harmonized and standardized methods for the analysis of the state of the eight threats to soil and their changes over time (soil monitoring), Based on this the eight threats can be related to the driving forces and pressures, cross-linking them with cultural, social and economic drivers, such as EU, national and other policies (e.g. in agriculture. transport, energy, environment, ...) as well as technical and ecological drivers (global and climate change). Based on this, an analysis of the impact of the 8 threats to soil (erosion, compaction, floods, salinization, sealing, contamination, decline in biodiversity, loss of org. matter) can be achieved, related them to the soil eco-services for other environmental compartments such as air, water, biomass production, human health, biodiversity and culture. After completing these research clasters it is possible to develop strategies and operational procedures to mitigate the threats. This means that responses can be given to alleviate the problems (Bloom, 2007).

Table 1: Concept for integrated research in ecology

CONCEPT FOR INTEGRATED RESEARCH IN ECOLOGY – EXAMPLE SOIL

	MAIN RESEARCH GOALS	RESEARCH CLUSTERS (see Fig. enclosed)	SCIENCES INVOLVED
1	To understand the main processes in the eco-subsystem soil; induced by threats	Analysis of processes related to the 8 threats to soil and their interdependency: erosion, loss of organic matter, contamination, sealing, compaction, decline in biodiversity, salinisation, floods and landslides	Inter-disciplinary research through co-operation of soil physics, soil chemistry, soil mineralogy and soil biology
2	To know where these processes occur and how they develop with time	Development and harmonisation of methods for the analysis of the **State (S)** of the 8 threats to soil and their changes with time = **soil monitoring** in Europe	Multi-disciplinary research through co-operation of soil sciences with - geographical sciences, - geo-statistics, - geo-information sciences (e.g. GIS)
3	To know the driving forces and pressures behind these processes, as related to cultural, social, economic, ecological or technical, local, regional or global developments	Relating the 8 threats to **Driving forces (D)** and **Pressures (P)** = cross linking with EU and other policies (agriculture, transport, energy, environment etc.)	Multi-disciplinary research through co-operation of soil sciences with political sciences, social sciences, economic sciences, legal sciences, historical sciences, philosophical sciences and others
4	To know the impacts on the eco-services provided by the sub-system soil to other environmental compartments (eco-subsystems)	Analysis of the **Impacts (I)** of the 8 threats, relating them to soil eco-services for other environmental compartments: air, water (open and ground water), biomass production, human health, biodiversity	Multi-disciplinary research through co-operation of soil sciences with geological sciences, biological sciences, toxicological sciences, hydrological sciences, physio-geographical sciences, sedimentological sciences and others
5	To have operational tools (technologies) at one's disposal for the mitigation of threats and impacts	Development of operational procedures for the mitigation of the threats = **Responses (R)**	Multi-disciplinary research through co-operation of natural sciences with engineering sciences, technical sciences, physical sciences, mathematical sciences and others

W.E.H. Blum and J. Büsing, 2004

PRODUCTION MODEL FROM THE ASPECT OF LAND RESOURCES PROTECTION

The production model from the aspect of protection of land resources based on an assessment of erosion processes according to the "USLE" method (Weischmeier and Smith, 1978) is established on the basis of the degree of erosion threat and slope on agricultural land (Zlatić, 1994). The degree of erosion vulnerability is defined as the ratio of actual and the tolerance of losses, which are determined on the basis of soil depth (Weischmeier and Smith, 1978).

On the slopes and under certain specific vulnerability of land suchproduction is projected that will bring down the losses of land below the tolerance limits, and will be based on the needs of the population and possible economic effects or profits. The structure of production by certain categories of the above model was implemented so that root crops are the most represented on unaffected land and mildest slope, while the areas under orchards are the smallest. An increase in erosion risk categories of land, as well as an increase in slope, enhanced the areas under new orchards, while crop rotation reduces the area under row crops, and increases the area under small grains and grass formations. Erosion crop rotations are designed for unaffected, vulnerable and poor medium threatened land, and represent a combination of row crops, small grains and grass formations. The intended row crops are corn, sunflower and soya. Small grains include wheat, oats and grass (on slopes up to 6 degrees and lands to medium vulnerability), while on higher slopes with a greater threat of land erosion a mixture of grass is provided (Table 2).

Study area: The Topciderska river Bain (Rakovica Municipality)

A part of this research is a study ofthe middle part of the TopčiderskaRiver basin, located within the boundaries of the municipality of Rakovica. Out of the total area of this part of the basin (1,858 ha), 1,361 ha belong to populated-city area, industrial area and traffic, and 497 ha are occupied by agricultural and forest areas with fragmented populated areas and access roads. The model of soil management for sustainability is applied on 339.63 ha of the agricultural land. The whole area is endangered by erosion processes. The processes of high erosion were recorded on steep slopes, which were formed probably by the effect of abrasion erosion when thePannonian Sea was withdrawing. About 26% of the area is under the processes of medium erosion, which is manifestedas mixed erosion with the formation of small gullies. Approximately 58% of the area is covered by low erosion (Kostadinov *et al.*, 1988). The total sediment yield from arable land is 10,843 t/year, while specific sediment yield amounts to 32 t/ha/year.

Table 2: Model of sustainable management of land resources

The degree of soil erosion vulnerability (SEUZ)	0-4°	4°-6°	6°-12°	12°-15°		>25°
				12°-18°	18°-25°	
Not endangered (SEUZ<1)	CR1+O	CR2+O	CR3+OST	CR4 OT	OT	P
Poorly endangered (SEUZ: 1.01-2.0)	CR5+O	CR6+O	CR7+OST	CR8 OT	OT P	P
Moderate endangered (SEUZ: 2.01-7.0)	CR9+O	CR10+O	CR11+OST	CR12 OT	P P	F
Very endangered (SEUZ: 7.01-28.0)	O	O+P	P	OT	P	F
Very strongly endangered (SEUZ>28.0)	P	P	P	P	P F	F

Source: Zlatić, 1994

Legend: CR1-CR12 – erosion control crop rotations; F - forests; O - orchards; OST – orchards self-terracing; OT - Orchards on the terraces; P – pastures

Ecological effects of soil management for sustainability

The ecological effects of soil management for sustainability are presented as the reduction of soil loss, i.e. the state after arrangement in comparison with the state before. Soil loss is calculated using the Universal Soil Loss Equation – USLE. Soil losses for the state before and after arrangement are presented in Table 3.

A significant reduction of soil loss is evident in the hilly part of Belgrade. In the Topčiderska River basin (in Rakovica community) the reduction is about 18 times (from 32.02 t/ha to 1.74 t/ha) (Fig.13.),

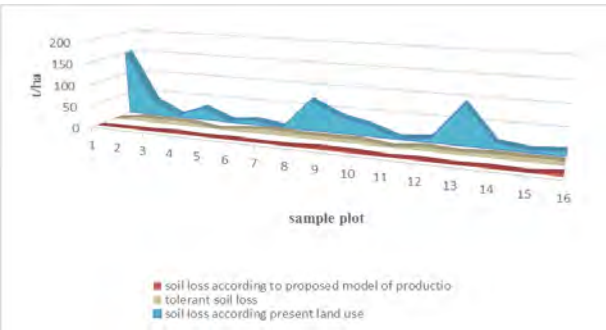


Fig. 13. Soil loss on the sample plots of Topčiderska River basin (Source: Original)

Economic effects of soil management for sustainability

Cost – Benefit analysis was used to present the economic effects of the model of SSM. In this respect the following methods were used:

- ❖ Internal Rate of Return (IRR),
- ❖ Pay Back Period (PBP),
- ❖ Costt – Benefit Ratio (C/B),
- ❖ Net Present Value (NPV).

The period of economic efficiency assessments is 15 years, as the average production period of stone fruit species. The results of economic efficiency are presented in Table 4.

Regarding the Internal Rate of Return (IRR), it is evident that there is significant efficiency. For the TopčiderskaRiver basin IRR is 17.86% which is above the RRR of 12% (effect is 5.86%). In terms of the Benefit – Cost Ratio (BCR) all three researched basins show satisfactory efficiency, as BCR is above 1. for TopčiderskaRiver basin in the Rakovica municipality, it is 1.16. According to the Net Present Value (NPV), TopčiderskaRiver basin in Rakovica showed significant efficiency of 356,964.71 €,

CONCLUSIONS

Paper includes strategies, lessons and experiences on SSL from the world and Serbia. A model of sustainable land resource management for the research area was applied in this research. This model is based on the planning of sustainable gr -forestry-fruit production, depending on the vulnerability of slopes to erosion. The ecological effects are satisfactory from the aspect of preserving land resources, because soil losses are reduced within tolerable limits according to this model. The sociological aspect included the needs of the population in the area, i.e., the production of food products was planned. The Cost-Benefit Analysis has shown an enviable economic profitability for a period of 15 years.

COMMUNITY BASED NATURAL RESOURCES MANAGEMENT (CBNRM) is presented using the example of the Grdelička Gorge area, based on the

Table 3: Soil loss for the state before and after arrangement

No	Watershed	Agricultural area(ha)	Soil loss				Decrease losses of soil
			Before arragement		After arragement		
			Sum (t)	t/ha	Sum(t)	t/ha	
1	Topčiderska river (Rakovica)	339.63	10.84	32.0	588	1.7	17.9 X

Source: Original

Table 4: Economic efficiency of sustainable soil

River Basin/Cost Benefit analysis	PBP (year)	C/B	IRR (%)	NPV (Eur)
Part of Topčiderska river	9	1.160	17.86	356,964.71

Source: original

participatory approach between the villagers of Grdelica, a Cooperative Enterprise and the Regional Chamber of Leskovac. The program was implemented using an established questionnaire, media and tribunes, which contributed to a consensus of all parties/stakeholders.

WOCAT was presented through the analysis of advantages, disadvantages and lessons learned of the example of cooperation between people and institution in South Serbia. DPSIR Approach was presented through implementation of operational tools in SWC.

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SALT-AFFECTED SOIL RESEARCH IN INDIA

– as seen from different viewpoints during a research career

Tibor Tóth*

Dear Colleagues! I warmly welcome the participants of the Joint International Conference on "Soil and Water Resources Management for Climate Smart Agriculture and Global Food and Livelihood Security" held this November in Pusa. Let me share my thoughts and enthusiasm with you on this occasion.

Long before arriving to India, to participate in a research project, did I meet and consult eminent Indian scholars. But before that, back home, at the Research Institute for Agricultural Chemistry and Soil Science in Budapest, Hungary, my peers explained me the significance of the salt-affected soil research in India. That was the high time of Indian-Hungarian cooperation on salt-affected soils, as a result of the activity of the eminent soil scientists of the twentieth century in the two countries. Those scholars gave me the proceedings of the Indo-Hungarian Seminars, Karnal (1977) and Hungaro-Indian Seminar on Salt-affected soils, Budapest (1980) to learn about the conditions. As young researcher I read with curiosity the reports and the detailed discussions, which were also carefully recorded and printed in the proceedings. The practical standpoint of the Indian colleagues was astonishing. Later at the institute in Budapest, I talked to several Indian scholars, working in India or overseas.

When at last, as fresh postdoc my time arrived to visit India, I tried to visit all major centres of salt-affected soil research throughout the vast country. During those many visits, as conference participant, lecturer or field/laboratory co-worker, there was ample opportunity to see how research is organized, carried out, presented and published. I was most delighted by the unforgettable hospitability of the colleagues who took me all over the country and accepted me as a visitor.

The first photo shows my earlier director, the late György Várallyay (Research Institute for Agricultural Chemistry and Soil Science of the Hungarian

Academy of Sciences, Budapest) in the middle and DC Joshi (Central Arid Zone Research Institute of Indian Council of Agricultural Research, Jodhpur) to the right and on the left the author. It was taken on May 29 in 1999 at the party of the Indian Embassy in Budapest.

Now, at this stage of my career as teacher, editor and official of organizations, again I see another side of the coin and write book reviews, decide on papers, prepare meetings, all with the participation of Indian researchers.

The different stages of my scientific career showed how Indian researchers argue, plan research, work in the field, analyse, write papers, present their research, write books, organize the life of technical societies.

Evidently, there is a distinct Indian way of doing all these things, when speaking about salt-affected soil research. For me it is a familiar feeling, after spending so long time there, mostly with CAZRI people in Jodhpur (Rajasthan).

Sincerity, dedication, perseverance - these are the characteristics, that come to my mind first and of course, hard working. I remember when, to my surprise, to bother people during their leisure time, my Indian co-worker reassured me that, state officers can be visited any time and we dropped in at a research station on a Sunday afternoon without

*Research Institute for Soil Soil Science and Agricultural Chemistry, Centre of Agricultural Research, Budapest, Hungary; Chairman of the Commission "Salt-affected soils" of the International Union of Soil Sciences, Editor-in-Chief of the journal Arid Land Research and Management.

any previous notice, and were warmly welcome by the chief researcher there. The scientific discussion went on as during work hours. I saw colleagues at breakfast, lunch and at dinner, such that I rarely do in other places.

I arrived at India to use new approaches and soon realized that the colleagues there had their proper ideas and means to improve salt-affected landscapes. I was particularly impressed by the care that was taken to instruct/assist the smallholder farmers to improve their subsistence agriculture.

Now as editor of the journal Arid Land Research and Management we publish papers on all aspects of soil salinization/reclamation. Our distinctive feature is to publish on the management of rainfed desert and semidesert natural and anthropologic ecosystems. Our papers cover ecology, agronomy and soil science. We regularly receive books from India for review also. Our editorial office is looking forward to receive more interpretive manuscripts from India to raise the level of the journal.

Being the elected chairman of the Commission "Salt-affected soils" of the International Union of Soil Sciences, my main task is to organize meetings. I am very happy to announce the next meeting of our commission, "First IUSS Conference on Sodic Soil Reclamation" which will be held in Changchun, China between September 17 and 19 in 2020. You are warmly welcome to present your research results there.

At the end of this greeting I insert two photos from my wall that I constantly ponder at.

The second photo shows a pokkali paddy close to Ernakulam, Kerala during winter time, when shrimp/fish is being cultivated. The long history and the environmental sustainability of this particular farming practice provides a very nice example for us, researchers in the twenty-first century. As you know well, there are several threats to this kind of cultivation and you can see the urban area approaching this particular site at the back of the photo.

The third photo shows the miracle of irrigation, in the neighbourhood of Hanumagarh, Rajashtan. The rice cultivation in the desert is profitable, but at the price of reducing downstream water availability and rising of watertable level. How long will this be sustainable in the long run? The answer to that question will be provided by you.

As during the last 72 years your peers did, I am sure that Indian soil scientists, civil engineers, agronomists and other fellow colleagues working on sustainable management of soils and waters participating in this conference will solve the problems, and with the help of the society, can provide food and livelihood security in your beautiful and friendly country. I wish success in this!

INTRODUCTION ON WASWAC

Basic Introduction

The World Association of Soil and Water Conservation (WASWAC), as one of the most influential academic society over the world, was established in USA in August 1983. In April 2015, its legal registration in China in 2015. The WASWAC secretariat is located in the International Research and Training Center on Erosion and Sedimentation (IRTCES), which is a category II center under the auspices of UNESCO.

The Aim

To promote the wise use of management practices that will improve and safeguard the quality of land and water resources so that they continue to meet the needs of agriculture, society and nature.

The Vision

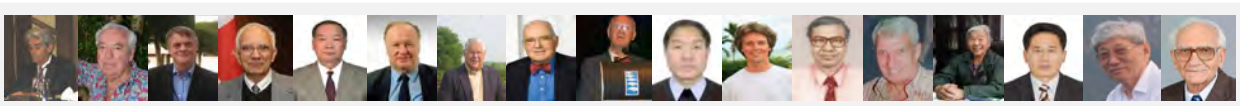
A world in which all soil and water resources are used in a productive, sustainable and ecologically sound manner.

The WASWAC Presidents

Time	President		Country
August 1983	Bill Moldenhauer		USA
1983-1986	Norman Hudson		UK
1987-1991	Rattan Lal		USA
1992-1997	Hans Hurni		Switzerland
1998-2001	David Sanders		UK
2002-2006	Samran Sombatpanit		Thailand
Jan-Mar 2005	Martin Haigh		UK
2007-2010	Miodrag Zlatic		Serbia
2011-2019	Li Rui		China

The Awards

WASWAC is in charge of the Norman Hudson Memorial Award, Distinguished Research Award, Distinguished Extension Award, Special Contribution Award, and Outstanding Youth Paper Award to candidates who have made outstanding achievements in soil and water conservation research, or have rich extension experiences and great impacts of promoting new technology application, or have made a great contribution to soil and water conservation in management, study or technique service at global or regional scale, or have made a great contribution to WASWAC or its journal of "International Soil and Water Conservation Research", or have submitted outstanding papers on soil and water conservation research written by young people with age less than 40 before the end of awarding year.



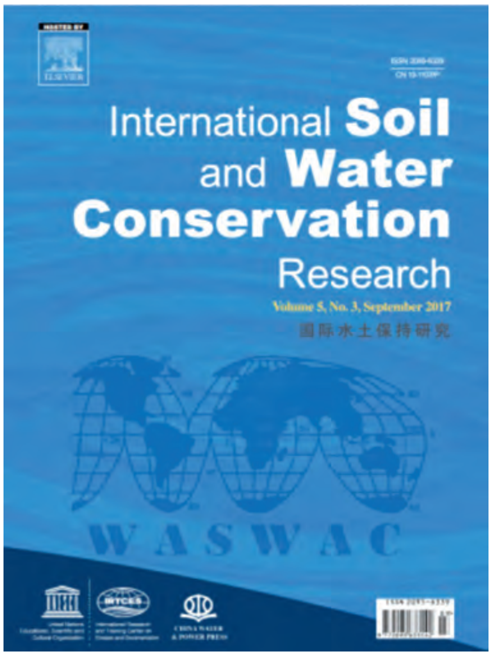
Some winners

The Publications

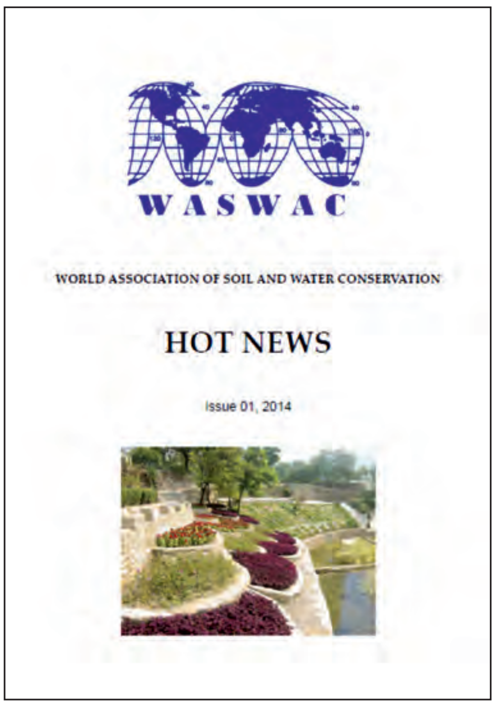
Since 2013, WASWAC started to publish peer reviewed English academic quarterly journal of "International Soil and Water Conservation Research"(ISWCR). Since 2019, this journal is indexed by SCIE. As an open access journal, all articles will be immediately and permanently free for everyone to read and download here:

http://www.keaipublishing.com/en/journals/international-soil-and-water-conservation-research/

WASWAC secretariat is published a monthly Hot News, to report on WASWAC news, global environmental event, abstracts for relevant books and papers, meetings announcement, etc.



The Journal of ISWCR



Hot News

WASWAC World Conference

WASWAC organizes a world conference every 3 years, to coincide with its official Council meeting and other technical meetings. The first three sessions were taken place in Xi'an, China in October 2010, in Chiang Rai, Thailand in September 2013, and in Belgrade, Serbia in August 2016, respectively. The fourth session will be held in New Delhi, India in November 2019.

WASWAC World Conference I (Xi'an, China, 2010)

WASWAC World Conference II (Chiang Rai, Thailand, 2013)

WASWAC World Conference III (Belgrade, Serbia, 2016)

International Youth Forum on Soil and Water Conservation

In order to help the youth worldwide to play greater roles in the scientific research, technological development, and demonstration & popularization of soil and water conservation, encourage and support the young generation to undertake the historical responsibility entrusted by the times, and to achieve sustainable development in soil and water conservation, WASWAC sets up the International Youth Forum on Soil and Water Conservation (IYFSWC) since 2015. It is organized every three years. The first two sessions was held successfully in Nangchang, China in October 2015 and in Moscow, Russia in August 2018.

WASWAC IYFSWC I (Nangchang, China, 2015)

WASWAC IYFSWC II (Moscow, Russia, 2018)

Regional seminars or training workshops

WASWAC organizes nonscheduled regional seminars or training workshops related to soil erosion, watershed management, SWAT, sustainable land management over the world.

SWAT Regional conference and training workshop (Guangzhou, China, 2011)

Sustainable land management seminar (Belgrade, Serbia, 2012)

Watershed management training workshop (Beijing, China, 2016)

WASWAC welcomes future cooperation and collaboration with sister organizations, including governmental and non-governmental agencies, universities, research institutes, and consultants in soil and conservation-related fields across the world.

Contact us

For more information on WASWAC, please go to www.waswac.org

Any problems and feedbacks please email us via waswac@foxmail.com

Scan QR code for WASWAC:

Scan QR code for ISWCR:

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INTERNATIONAL SOIL CONSERVATION ORGANIZATION (ISCO)
HISTORY AND PURPOSE

Samir A. El-Swaify
Emeritus Professor
University of Hawaii at Manoa
and
Coordinator, ISCO's Board of Directors

The founding of ISCO was an outcome of three conferences that assembled international groups of scientists with a common interest in addressing the most serious cause of global soil degradation, namely soil erosion (De Boodt and Gabriels,1980; Morgan, 1981 and El-Swaify et al, 1985). Following substantial debate, participants at the latest of these conferences, held in Honolulu, Hawaii in 1983, decided that there was sufficient justification to form an independent society whose **"primary charge is to oversee the organization of future international soil conservation conferences".** The society's mission would be to provide dedicated continuity to the sharing of up-to-date, multidisciplinary information among scientists and professionals in this vital area.

The purpose of the International Soil Conservation Organization, therefore, is to promote the sustainable, productive, conservation-effective and efficient use of soil and water resources. It does so through communication among participants in its meetings, the goal of which is to improve understanding of natural resource management issues. Publishing the proceedings of ISCO conferences is a top priority.

A primary feature of ISCO is the "informal" organizational structure whereby no official "Officers", "Constitution," "Bylaws," or membership fees are formulated or enacted. Theresponsibility for organizing a conference resides mainlywith the host country, institutions, and individuals, including the chief host who would be designated as the current ISCO President. The Board of Directors is composed of past ISCO presidents, representatives of sister global or regional societies and invited distinguished scientists. Among its responsibilities, is to evaluate host country invitations, to assist conference organizers with planning when needed, and to identify potential host countries through their contact networks. A set of organizational guidelines to help conference hosts was ratified in 1999 by the Board (https://www.tucson.ars.ag.gov/isco/). Conference themes deemed relevant to ISCO and the host country are encouraged and are left to the discretion of the host.

Using this operational model, ISCO has thrived by holding 19 highly successful conferences hosted by many countries in all inhabited continents. Many have been published in accessible proceedings.

Please enjoy your participation in this upcoming conference in New Delhi which will be the 20thISCO Conference. You are also invited to visit the above ISCO Website for many more details on ISCO's history, modus operandum and products.

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SOIL CONSERVATION SOCIETY OF INDIA-AT A GLANCE

Suraj Bhan
President, SCSI

BACKGROUND

Soil Conservation Society of India was established at Hazaribagh, Bihar (now in Jharkhand) in December 1951, at the first National Symposium on Soil Conservation organized by the first multidisciplinary Department of Soil Conservation created by the Damodar Valley Corporation, on the pattern of the Tennessee Valley Authority (USA). The society was registered at Patna, Bihar vide No. 14/1952-53 under the Societies Registration Act of 1860.

OBJECTIVES

- Survey and assessment of natural resources of the country in a systematic manner using modern techniques of remote sensing, computerized interpretation for conservation and development programmes.
- Promote technical and latest advanced knowledge of soil and water conservation livestock, Micro flora, Frow Forest and management practices for land degradation, rainwater harvesting, runoff and control peak of water for all sustainable agriculture production systems. (including Bio-industrial Watershed Management).
- Promotion and implementation of integrated watershed management approach through the people's and Government involvement.
- Coordination and implementation of all matters relating to soil and water conservation and Management with reference to ecology and biodiversity among the various agencies—viz government and non-government organization in order to facilitate policies of the Central State Government for Food Security and Agricultural sustainability.
- Development and management of micro water resources as a vital pre-requisite of bio-production, forestry, animal husbandry and fisheries, land management, rural development, environmental protection and other bio-resources uses and conservation programmes within watersheds.
- Developing programmes of ecology, agriculture, for enhancing sustainability for rural development livelihoods to improve incomes through integrated farming system and bioindustrial watershed approach, processing agricultural produce, value addition, Market networking in the watersheds.
- Judicious and Scientific proper soil and water conservation, development and management in the irrigated and rainfed area.
- Development of Soil and Water Conservation in the rainfed areas for enhancing land productivity and harnessing rainwater.

ACTION & ACHIEVEMENTS

Publications

The Society has also brought out a number of publications based upon the papers presented in its National and International Seminars and Conferences. Besides, the society has published more than 13 books on watershed development, conservation farming, wasteland development and other related topics on soil and water conservation.

Journal

Society brings out quarterly Journal of Soil & Water Conservation and quarterly Newsletter Soil & Water Conservation Today. The research papers are received from the experts, scientist, researchers and students are published in this journal which are duly scrutinized and recommended by the referee on different topic and different suitable topic which are consider in this journals.

Library

The Society maintains a library which has more than 2000 books technical on various subjects relating to the Natural Resources, Conservation, Development, Management, Success Stories, bulletin, journals, pamphlets, proceeding of various conferences and other miscellaneous literature.

Seminar, Conference, Workshop

The SCSI has been organizing National and International Conferences, seminars and workshops at various places of the country. Till date, the society has organized 28 National, 3 International Conferences and 1 Asian Congress successfully and 4th International Conference is being organized in November 5-9, 2019 at New Delhi on various subjects.

Members

The membership of the society is open to individuals, institutions and organizations serving for welfare of the farming community and conservation of natural resources. The society is having at present 3100 life and annual members, 57 institutional members and more than 500 student members.

State Chapters

The Society extended its activities by establishing state Chapters in various parts of the country. Currently, 23 state Chapters of the SCSI are functioning namely (1) Andhra Pradesh (2) Arunachal Pradesh (3) Assam (4) Bihar (5) Rajasthan (6) Chhattisgarh (7) Gujarat (8) Jammu & Kashmir (9) Karnataka (10) Kerala (11) Madhya Pradesh (12) Maharashtra (13) Meghalaya (14) Mizoram (15) Nagaland (16) Orissa (17) Punjab (18) Tamil Nadu (19) Telangana (20) Tripura (21) Uttrakhand. (22) Uttar Pradesh (23) West Bengal.

Memorial Lecture

The society has been organizing the memorial lectures to commemorate the founder member, eminent soil scientist and Soil Conservationist in India so far Dr. Y.P. Bali and Prof. J. S. Bali Memorial lectures have been organized.

Awards

In order to encourage the talent in all fields of research and development engage for the cause of conservation and management of the land, water and other natural resources, the Society honouring them by giving awards. The awards instituted by the Society to recognize dedicated services of the professionals and scientists by conferring them with various awards

List of Awards

(i) **Classified Awards**

A. Bhu Ratna Award Bi-Annual
B. Life Time achievement Award
C. National fellow Award
D. Gold Medal Award
E. Leadership Award
F. Student Incentive Award
G. Communication Book Award
H. Special Research Award

(ii) **Unclassified Awards**

A. Special Honour
B. Honorary Membership Award
C. Sponsored Awards

Consultancy

- The Society continued and expended its consultancy work and try to get foreign consultancy work by expanding contacts with the Foreign Aid Agencies and Embassies
- The country like USA. Australia, Zimbabwe, Egypt, Libya, Germany, Scotland part of UK, Russia, China, Brazil, Argentina etc. are the nations where soil conservation is considered as an important area and the society is focusing to get consultancy from them.
- Proposing the State Governments to initiate a Study Programme on Bioindustrial Watershed Management in order to increase the net profits of the farmers and their farming occupation.

Evaluation Studies

The SCSI has also undertaken several evaluation/ impacts studies on watershed development programmes implemented by the central Govt. through state govt. SCSI has also been identified as Resource Organization by National Rainfed Area Authority (NRAA), Planning Commission, GOI for conducting training programs for Junior/Middle/ Senior Level Officers in North-Eastern States of India under Integrated Watershed Management Programme (IWMP) and so far, the society has completed all the assigned works in eight states as per the assignment by NRAA, Govt. of India

Website

The dynamic website of the society has been created which is http://scsi.org.in and functioning well.

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Co-Chair	:	Prof. Samir A. El Swaify (ISCO), USA
		Prof. Li Rui, President, (WASWAC), China
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