2017 SOUVENIR

NATIONAL SEMINAR

On

Smart Farming for Enhancing Input Use efficiency, Income and Environmental Security (SFEIES)

(September 19-21st, 2017)

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Jointly Organized by :

Indian Association of Hill Farming and ICAR Research Complex for NEH Region

Umiam, Meghalaya

Disclaimer

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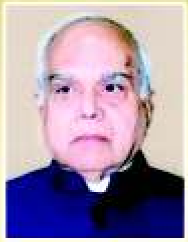
MESSAGES



Banwarilal Purohit
Governor

RAJ BHAVAN
SHILLONG - 793001
MEGHALAYA INDIA

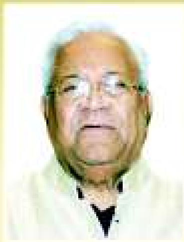
MESSAGE

It gives me pleasure to learn that ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya is organizing a National Seminar on " Smart farming for enhancing input use efficiency, income and environmental security", from 19th to 21st September, 2017 at Umiam, Meghalaya.

North Eastern region is a global hotspot of biodiversity. The efforts of the organizers, both the Indian Association of Hill farming and ICAR Research Complex for North Eastern Region, Umiam, Meghalaya in organizing a national seminar on "Smart farming for enhancing input use efficiency, income and environmental security" is a well- timed event and is the need of the hour.

I wish the organizers all the very best for the success of the seminar.

(Banwarilal Purohit)



P. B. ACHARYA
GOVERNOR, NAGALAND &
ARUNACHAL PRADESH

RAJ BHAVAN
ITANAGAR-791 111

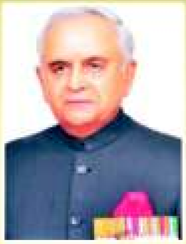
MESSAGE

I am pleased to learn that Indian Association of Hill Farming and ICAR Research Complex for North Eastern Hill Region are organizing a National Seminar on 'Smart farming for enhancing input use efficiency, income and environmental security from 19th to 21st September 2017 at Umiam, Meghalaya. I am hopeful that this seminar will provide the much needed platform to discuss the challenges in the agriculture and allied sectors and also explore sustainable methods to address it.

The future of agriculture sector is going to be more challenging in order to feed the burgeoning population with minimal resources utilization. Agriculture must be sustainable, costly effective and environmentally friendly to secure future of humanity. Smart farming has the potential to utilize the high-tech farming techniques and technologies for enhancing production while minimizing cost and preserving resources.

On behalf of people of Arunachal Pradesh, I convey warm greetings to the organizers and participants. I wish the National Seminar a grand success.

(P. B. ACHARYA)



Lt Gen Nirbhay Sharma
PVSM, UYSM, AVSM, VSM (Retd)
Governor
Mizoram

RAJ BHAVAN
Aizawl – 796 001
India

MESSAGE

I am happy to know that the Indian Association of Hill Farming in collaboration with ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya is organizing a National Seminar on "Smart farming for Enhancing Input Use Efficiency, Income and Environmental Security" from 19th to 21st September, 2017 at ICAR Research Complex for NEH Region, Umiam, Meghalaya.

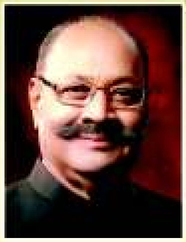
The theme identified for the National Seminar is quite appropriate as the farming landscape is changing significantly, and entering a new era of technological change to meet the population growth, climate change, changing diets, and competition for resources. Smart farming takes developments in engineering and associated technological innovations and opens up new vistas of support and intervention, not only in the established disciplines of arable and livestock farming, but also in the emergent areas of urban and integrated farming. This farming has a real potential to deliver a more productive and sustainable agricultural production, based on a more precise and resource-efficient approach.

I hope that this National Seminar will provide an excellent platform for the researchers, policy makers, entrepreneurs and other stakeholders to deliberate on the issues which are critical for improving agricultural and environmental sustainability

I congratulate the organizers and all the participants and wish the event a grand success.

Nirbhay Sharma ..
(Nirbhay Sharma)

Date: 23rd August, 2017



श्रीनिवास पाटील
SHRINIWAS PATIL
Governor of Sikkim

RAJ BHAVAN
Gangtok – 737103
(Sikkim)

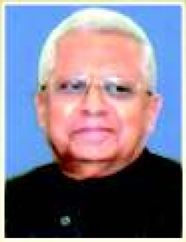
MESSAGE

The North Eastern region is bestowed with a diversity of agro-climatic conditions, offering vast potential for producing a wide range of agricultural and horticultural crops. The vision of the Government in doubling the farmers' income by 2022 could be achieved by focussing on technology-led efficient SMART farming. Certainly there are several smart farming technologies which can boost the economy and open up entrepreneurial avenues with inclusive growth of the agrarian community of our country.

I compliment the initiatives and lead taken by Indian Association of Hill Farming in conceptualizing and organising a National Seminar on 'Smart Farming for enhancing input use efficiency, income and environmental security' from 19-21 September, 2017 at ICAR Research Complex for NEH Region, Umiam, Meghalaya.

I wish Seminar a grand success.

S.Patil
21-8-17.
(Shriniwas Patil)



तथागत राय
राज्यपाल
TATHAGATA ROY
Governor

सत्यमेव जयते
RAJ BHAVAN
AGARTALA-799 006

MESSAGE

It is a pleasure to learn that the Indian Association of Hill Farming and ICAR Research Complex for North Eastern Hill Region are organizing a National Seminar on 'Smart farming for enhancing input use efficiency, income and environmental security' on 19th to 21st September, 2017 at Umiam, Meghalaya.

I convey my best wishes to the organizers a great success in the conduct of the seminar and the publication of the souvenir.

(Tathagata Roy)

Sarbananda Sonowal

सत्यमेव जयते

Chief Minister, Assam
Guwahati

MESSAGE

It gives me immense pleasure to know that Indian Association of Hill Farming and ICAR Research Complex for North Eastern Hill Region are organising a National Seminar on 'Smart farming for enhancing input use efficiency, income, and environmental security' from 19th to 21st September, 2017 at Umiam, Meghalaya. I am also glad to note that a souvenir is going to be published to mark the occasion.

As the three day Seminar seeks to provide a platform to scientists, policy makers, NGOs, farmers, and students from across the hill ecosystems of the country to deliberate on agricultural scenario in the context of Look East Policy and technology driven smart farming to increase farm income; it is imperative for all stakeholders to build a bridge between the farmers and agricultural researchers for ensuring livelihood and environmental security of the region.

I hope that the National Seminar opens up newer dimensions in bringing science and innovation to the help of the farmers. I extend my best wishes to the organisers for this endeavour.

(Sarbananda Sonowal)

N. Biren Singh

सत्यमेव जयते

Chief Minister, Manipur
Imphal

N. Biren Singh

MESSAGE

I am pleased to learn that the Indian Association of Hill Farming and ICAR Research Complex for NEH Region, Umiam Meghalaya is organising a National Seminar on "Smart Farming for Enhancing Input Use Efficiency, Income and Environment Security" from September 19-21, 2017 at Umiam, Meghalaya.

The world's population is growing rapidly with a corresponding increase in demand for natural resources, food, feed and fiber exerting enormous pressure on agriculture to meet the consumption need and to produce more in a sustainable manner. The scenario becomes more critical as the production target has to be achieved against the dwindling and limited availability of natural resources like arable lands, water, fossil fuels etc. and and other less predictable factors, such as the impact of climate change.

To address such issues and increase the quality and quantity of agricultural production without any negative effect on the environment, the agricultural / farming practices needs to be smart using new and more precise tools. Smart Farming technology has a real potential to deliver a more productive and sustainable agricultural production, based on a more precise and resource-efficient approach. Smart farming is the movement of the moment. As such, I strongly feel that it is relevant to organise such a National Seminar at this juncture.

I extend my warm greetings to the organisers and participants and wish the Seminar a grand success.

20/8/17

(N. Biren Singh)

सत्यमेव जयते

Chief Minister, Nagaland
Kohima

T.R. Zeliang

MESSAGE

I am happy to note that the Indian Association of Hill Farming and ICAR Research Complex for North Eastern Hill Region is organizing a National Seminar on 'Smart farming for enhancing input use efficiency, income and environmental security' during 19th – 21st September, 2017 at Umiam, Meghalaya.

Agriculture in North Eastern Region is faced multiple challenges such as climate change, soil degradation, soil erosion, hilly terrain, poor connectivity, lack of post-harvest storage facilities, market linkages and food processing units. The agriculture pattern in North Eastern Region needs to be supported by modern technology, farm mechanization and infrastructure facilities to foster higher growth in agriculture and allied sectors.

I am sure the event will be focusing more on improving the agriculture productivity in NE Hill Region and recommended measures to make the hill farming into self-reliant and technology led vibrant system.

I convey my heartfelt appreciation to the Indian Association of Hill Farming and ICAR Research Complex, Umiam for organizing the National Seminar and bringing out a souvenir.

I wish the event a grand success.

(T.R. Zeliang)

सत्यमेव जयते

Chief Minister, Mizoram
Aizawl - 796 001

LAL THANHAWLA

MESSAGE

North eastern hill agriculture is influenced by high amount of rainfall, steep slope and rapid urbanization leading to loss of natural resources, loss of biodiversity, occurrence of drought, floods, infestation of pest and diseases. The threat posed by climate change is much too real to be ignored today. Agricultural and allied sectors are the first to experience its negative impacts. The farming community of our country is most vulnerable, being affected by the effects of global change. Given this situation, formulating a climate smart farming system for enhancing crop productivity and to increase the resilience of agriculture in the region is the need of the hour.

I congratulate the IAHF & ICAR Research complex for NEH Region, Umiam for organizing this National Seminar to address the most challenging issue and I wish the seminar grand success in terms of coming out with practicable suggestions and solutions to deal with the emerging threats to environmental security along with food, nutrition and livelihood security.

Dated - Aizawl
29th August, 2017

(LAL THANHAWLA)

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

सत्यमेव जयते

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 110 001

E-mail: dg.icar@nic.in

MESSAGE

It gives me immense pleasure to know that Indian Association of Hill Farming and ICAR Research Complex for NEH Region, Umiam, Meghalaya are organizing seminar on "Smart farming for Enhancing Input use Efficiency, Income and Environmental Security" in Meghalaya during 19-21 September 2017. Indian agriculture is going through a massive modernization programme in research and technology development, skill development, soil health card, insulating farmers against crop failure through crop insurance, agri-infrastructure, use of ICTs and interlinking of the markets across the country. All these efforts are directed towards increasing production, reduce the post-harvest losses, boost agricultural trade and enhance the farmer's income- at least doubling it by 2022. Under the look east policy, Government of India has envisioned to start the Second Green Revolution in the Eastern India. The region has the bounty of natural resources to trigger such a revolution. The region has nearly achieved self sufficiency in food grain production and it is high time to tap other potential sectors like horticulture, piggery, medicinal plants and fisheries. Organizing such a relevant seminar in the North East India is commendable. In the context of agriculture in the north east hill region, strategic cropping in typical niche climates could be an important intervention along with Precision Agriculture, farm automation and ICAT which are integral parts of smart farming.

I hope all the flagged themes shall be deliberated comprehensively in the seminar and wish all the success for the seminar.

(Trilochan Mohapatra)

राम मुईवा, आई.ए.एस.
सचिव
भारत सरकार
उत्तर पूर्वी क्षेत्र विकास मत्रालय
उत्तर पूर्वी परिषद

RAM MUIVAH, I.A.S.
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF DEVELOPMENT
OF NORTH EASTERN REGION
NORTH EASTERN COUNCIL

MESSAGE

I am delighted to learn that Indian Association of Hill Farming in collaboration with ICAR Research Complex for NEH Region, Umiam, Meghalaya is organizing a National Seminar on **'Smart Farming for Enhancing Input Use Efficiency, Income and Environmental Security'** from 19th – 21st September, 2017 at ICAR Research Complex for NEH Region, Umiam, Meghalaya. I compliment Dr. S.V. Ngachan, Director, ICAR, NER, Umiam and his colleagues for organizing such important and useful National Seminar on smart farming.

Each second, the world's population grows by nearly three more people, that is 2,40,000 people a day. This means there will be an extra billion mouths to feed within the next decade. Securing enough food for the exploding world population in a sustainable and environment friendly way is a herculean task. Smart farming will be the farming of the future: a hi-tech and cost effective system of growing food. It has the potential to considerably increase output per unit of natural resources.

I wish the National Seminar a grand success.

(Ram Muivah)

DR. K.M. BUJARBARUAH
ARS, Ph.D, FNAAS, Dsc(Hc)
VICE-CHANCELLOR

ASSAM AGRICULTURAL UNIVERSITY
JORHAT- 785 013
ASSAM (INDIA)

MESSAGE

We are all aware that with the changes taking place in the environment, climate, food production base and inputs (soil water, biodiversity, farm labor, chemical input etc.), consumer preference and market demand; our agricultural methods, methodologies, tools, and techniques have also to undergo corresponding changes from traditional to technology driven one, from lethargic and non-remunerative mono cropping to smart farming one where resources and inputs can work in harmony and provide stability, sustainability and economic empowerment. This is more so for areas like Eastern and western Himalayas where challenges are many with explorable farm opportunities and in that context, holding of the present seminar on 'Smart farming for enhancing input use efficiency, income and environmental security (SFEEIES) at ICAR Research Complex if very timely. I am sure the deliberations will lead to a smart farming road map for us to follow.

I wish the seminar all success.

(K.M. Bujarbaruah)

Prof. M. Premjit Singh
Vice-Chancellor

CENTRAL AGRICULTURAL UNIVERSITY
IROISEMBA, IMPHAL-795004, MANIPUR (INDIA)

MESSAGE

In the recent time, the agricultural system of the whole world is going through challenging phase. The reasons are very obvious to everyone starting from farmers to policy makers viz., climate change, depletion of water table, soil erosion, etc. In this challenging scenario, there is an urgent need to transform the traditional way of farming to SMART farming. It requires precise and timely information along with other inputs for efficient agricultural operations. SMART farming will help to optimize the use of agricultural inputs leading to enhanced productivity and subsequently environmental sustainability.

I am happy to know that Indian Association of Hill Farming along with the ICAR Research Complex for NEH Region, Umiam is organizing a National Seminar on "Smart Farming for Enhancing Input Use Efficiency, Income and Environmental Security" during 19-21 September, 2017 at Umiam, Meghalaya,

I wish the Seminar a grand success.

16/8/2017
(M. Premjit Singh)

Dr. S.V. Ngachan
Director

भारतीय कृषि अनुसंधान परिषद्
उत्तरपूर्व पर्वतीय कृषि अनुसंधान परिसर,
उमियाम, मेघालय-७९३ १०३

Indian Council of Agricultural Research
ICAR Research Complex for NEH Region
Umiam, Meghalaya-793103

MESSAGE

It is highly satisfying to be part of the national seminar on "Smart farming for Enhancing Input use Efficiency, Income and Environmental Security" organized by the Indian Association of Hill Farming and ICAR Research Complex for NEH Region, Umiam, Meghalaya in Meghalaya during 19-21 September 2017

The agriculture in the North Eastern Hill region is Complex, Diverse and Risk prone. The anthropodgenetic activities in various ways are also causing degradation of natural resources and put pressure on the prevailing weather behavior. Frequent aberration in weather pattern and occurrence of meteorological extremes are posing even more serious threat to the already low profit agriculture sector. We are to overcome a great challenge to double the income of farmers by 2022 and to produce 108 million tons more by 2050. As the hill agriculture is fragile, and has lesser adaptive capacity to climate change, innovations and smart options are necessary to meet the challenges of future climate change. The production system has to produce more to feed the expanding population while maintaining the ecological functions for the survival of mankind.

I am confident that the National Conference would be facilitating wider discussions on such relevant and emerging issues, and the recommendations will help in optimizing management systems for the welfare of the farming community.

I extend my best wishes for the great success of the seminar.

(S.V. Ngachan)

Dr. A.K. Tripathi
Director

भा.कृ.अनु.प.- कृषि प्रौद्योगिकी
अनुप्रयोग अनुसंधान संस्थान, अंचल -६
भारतीय कृषि अनुसंधान परिषद
के.रो.फ.अनु.सं. केम्पस,
काहिकुची, गुवाहाटी - ७८१०१७

ICAR-Agricultural Technology Application Research Institute, Zone-VI
Indian Council of Agricultural Research
CPCRI Campus, Kahikuchi, Guwahati-781 017

MESSAGE

The future of agricultural sector is going to be more challenging in order to feed the burgeoning population with minimal resource utilization. There is the need of an agricultural panacea which must be sustainable, cost-effective and environmentally friendly. So what will be that solution? Welcome to smart farming. It has the potential to utilize the high-tech farming techniques and technologies for enhancing production while minimizing cost and preserving resources.

Smart farming is also an opportunity in cities. In urban areas, lack of vacant plots of land is driving more and more urban farmers to produce food upwards on the side of buildings rather than outwards. This vertical farming is a spatially efficient option for urban food production, which can be made smart by the use of information technology to time and target inputs. If successful, it has the potential to increase agricultural production, improve small farmers' competiveness and provide a growing urban population with fresher produce.

I am pleased to note that Indian Association of Hill Farming in collaboration with ICAR Research Complex for NEH Region, Umiam is organizing National Seminar on "Smart Farming for enhancing input use efficiency, income and environmental security" during 19-21st September, 2017 at Umiam, Meghalaya. I complement the organizing team to make this event a grand success.

(Dr. A. K. Tripathi)

Bidyut C. Deka
Director

भा.कृ.अनु.प.- कृषि प्रौद्योगिकी
अनुप्रयोग अनुसंधान संस्थान
भारतीय कृषि अनुसंधान परिषद
उमियम (बड़ापानी),
रि-भोई, मेघालय - ७९३१०३

ICAR-Agricultural Technology
Application Research Institute
Indian Council of Agricultural Research
Umiam (Barapani), R-Bhoi, Meghalaya - 793 103
(ISO 9001:2015 Certified Organisation)

MESSAGE

The future of agricultural sector is going to be more challenging in order to feed the burgeoning population with minimal resource utilization. Agriculture must be sustainable, cost - effective and environmentally friendly to secure future of humanity. Smart farming has the potential to utilize the high-tech farming techniques and technologies for enhancing production while minimizing cost and preserving resources. I am pleased to note that Indian Association of Hill Farming in collaboration with ICAR Research Complex for NEH Region, Umiam is organizing National Seminar on "Smart Farming for enhancing input use efficiency, income and environmental security" during 19-21st September, 2017 at Umiam, Meghalaya. I complement the organizing team to make this event a grand success.

28/8/17
(Bidyut C. Deka)

Content

Water Farming for Food Security and Doubling Farmers' Income — Road Ahead

K M Bujarbaruah

Vice Chancellor,
Assam Agricultural University

On Water Farming

The issue of less and lesser amount of water availability to the water thirsty sectors including the domestic sector is ringing the alarm bell for an impending crisis like situation. In 1951, per capita water availability was 5177 m^3 per annum which came down to 1820 m^3 in 2001 and further to around 1700 m3 now. Of the available water, 89 percent was used for agriculture, 8 percent for domestic and 3 percent for industrial purposes. This availability for agriculture came down to 78 percent and is projected to go down further to around 70 percent by 2025 limiting thereby our capacity to provide food security to our population thus making water security an indicator of food security which is why our Hon'ble Prime Minister is talking about 'More Crop per Drop' to sustain food security. Planning Commission, Government of India is also revisiting its draft policy on water and several brainstorming discussions are currently under way to develop a suitable policy matching with the exponentially growing demand for water in a growing economy like India. As per the estimate of Central Water Commission (CWC) 2014, although the country receives around 4000 billion cubic meter (BCM) of water annually, the total renewable water resource is 1896 BCM of which the utilizable water resource is only 1123 BCM (690 from surface and 433 BCM from ground water resources) and as we learn now, this amount of water is not going to be sufficient by 2025 when we see the estimate of International Water Research Institute (IWRI) which stipulates that domestic water demand per person per annum by 2025 in urban areas will be 80 m3 and for rural areas 50 m3. Going by this requirement for the likely population by that year, one can imagine the water demand in the country for domestic purposes alone. And considering the requirement of around 500 litre of water to produce one kilogram of plant dry matter and 4000 litre for the production of one kilogram of rice, the state like Assam and other North Eastern states pursuing rice centric agriculture with minimum level of irrigation will have to think and act seriously towards strengthening their policy and technology base for water harvesting and management with focus on improving water productivity in each crop.

India has 12 major river basins with a cumulative catchment area of around 253 million hectare of which the major catchment of 110 Mha falls under Ganga-Brahmaputra-Meghna system. Another 48 medium rivers cover a catchment area of 25 Mha. This river system is the major source of surface water potential of the country and unfortunately the water holding capacity of this river system is diminishing under the influence of heavy silting. While clean Ganga project is likely to restore this capacity back, a similar project for the river Brahmaputra is needed urgently. If the rivers Brahmaputra and Barak with an area of 6300 sq.km in Assam are dug by 10 feet, one can imagine the increase in water storability and the availability of conserved water which can be traded to neighbouring states. Coupled with this, one can also imagine the quantum of crops saved which otherwise is lost annually due to flood which is basically a result of these two rivers not presently possessing the capacity to hold the flood water. The 3rd benefit will be accruing from using the conserved water in these two rivers for supplementary *kharif* irrigation during periodic droughts as well as from growing additional *ravi* crops. Yet another benefit will be in the form of lesser impact on soil erosion in the principle of deeper the rivers lesser is the erosion. This single intervention with 4 fold benefits will definitely justify one time massive investment in de-silting these two rivers and open the gate for commercial water farming and if done in right earnest, human being, livestock, fish, crops and industries will all be benefited. Hence it needs to find a place in the water policy of government of India. Having said the above, it is also true that we cannot and definitely should not pass on the responsibility to government machinery alone. We have to do our part of the job and the job is how best we can devise scientific means and methods to increase the volume of utilizable water by another 500 BCM. We have two options for this - one by reducing the evapo-transpiration loss from the present level of 2000 BCM to 1500 BCM thus saving 500 BCM of water or - two by increasing the quantity of utilizable water from 1123 BCM to 1623 BCM by macro and micro manipulation of annual natural flow of 1869 BCM since the difference between this (1869) and utilizable water (1123) is 746 BCM i.e by reducing this difference to 246 BCM. Similarly, we will have to pursue research agenda seriously to develop crop and animal varieties with higher water use efficiency. We need to simultaneously work on all these and other options applying 21st century science.

Pending the initiation of research process on the above options, we need to immediately develop our water foot print data in the line of carbon foot print information that have been generated already by the developed economies. This will help us in water budgeting and generating awareness among the water users. Yet another new concept is Virtual Water Content (VWC) which is the volume of water that is used to produce a commodity and is measured in the place where the commodity is actually produced. People have started thinking in the line of water gardening that is importing water intensive products with high VWC from other countries so as to save its own water resources in the form of water farms. Use and re-use of waste water and the marginal water from bathrooms and toilets is another emerging area where we have to develop our expertise locally and regionally. Meanwhile, all the Research, Development and educational institutions in the country need to showcase the established technologies of improved water application like *in* and *ex situ* water conservation for rain fed agriculture, drip and sprinkler irrigation system, fertigation system and the likes. It is now known that drip irrigation saves upto 50 percent of water, sprinkler upto 40 percent, SRI method of rice cultivation upto 40 percent, aerobic method of rice production upto 50 percent of water. Drip today is possible even for rice farming. The system of water farming like *jal kund* needs to be propagated even for livestock farming and these facilities could be created under MNREGA programme.

If we do not wake up now and embrace water farming and its sanctified use, it might be too late since water scarcity issue to agriculture, due to increased competition from the domestic and industrial sectors compounded with global warming and adverse impact of climate change, is becoming graver and graver. Today every drop of water matters and therefore saving it, utilizing it as judiciously as possible should be a matter of concern for all of us.

On Doubling Farmers' Income:

The desire of our Hon'ble Prime Minister to double the income of our farmers by 2022 has to be taken with all the needed seriousness both for realizing his dream and benefiting the farming community in the process. Once Mahatma Gandhi had said, To a hungry man, God comes in the form of Bread. This hungry man could be an economically underprivileged one or even a billionaire depending on the situation. The point to bring home is FOOD and its importance irrespective of one's standing and this food producer is today experiencing multiple obstacles ranging from environmental issues to a good price for his harvest. On the face of these obstacles, how we proceed to double his income is the core issue. Notwithstanding the argument as to whether this proposed income increase is in nominal term or real time income, let us analyze how we go about it.

We need, first of all, to understand that a farmers income does not come from the farm alone. A farmer also does other jobs like running a *pan* shop, having a road side tea stall or working in MNREGA type of programs. Supposing, out of an income of Rs.100 in a day, Rs.70 and Rs.30 comes from farm and non-farm sources respectively, the income doubling target will have to cover both these sources of income i.e Rs70 has to be taken to Rs.140 and Rs.30 to Rs. 60. Stakeholders engaged in delivering the farm deliverables will be responsible for doubling the farm income and other players for the non-farm part of the income.

Going by the milestone fixed, we have exactly 5 years time from now to achieve the target. We will have to start from this year itself (AAU has started in a modest way through the KVKs) for which following go ahead path is suggested :

- Select at least 20 districts, for first two years, identifying 2 villages in each under 2 cereal crops, 4 horticultural crops, 2 spices and 2 flower crops besides cattle, goat, pig, poultry and 1 fish crop enlisting the cropping pattern followed therein and the niche/ commercially attractive crops of the village together with diversification options and then assess the current level of farmers income in the selected villages based on their categorizations like small, medium and large.
- Immediately after identification of the villages applying PRA type of technique, carry out soil quality assessment together with nutrient application schedule, water availability and quality, quality of seed (including animal and fish seeds) and planting materials used and identify intervention points.
- After their identification, arrange village wise awareness and training including skill development program.
- Simultaneously, assess support needs in a realistic way taking into consideration the accessible support from the already launched GoI schemes like Pradhan Mantri Krishi Sinchai Yojina, Fasal Bima Yojona, Soil Health Cards, RKVY, MNREGA, Technology Missions both on Animal and Horticulture as well as programs under NFDB (National Fisheries Development Board) etc and also articulate the linkage chain among these schemes. Separate demands for additional support that might be needed may also be placed to the Ministry of Agriculture.
- Since entire North east is being converted to organic mode of agriculture, plan the interventions accordingly right from seed to other inputs like fertilizers/ pesticides promoting thereby non-farm sector income growth through their production.
- Prepare contingency plans, arrange short and medium range weather forecasting, use ICT for technology and information (including fund utilization aspect) delivery right at the village community centre, demonstrate resource efficiency doubling methodologies and also attend to farmers stresses by minimizing their labor through suitably designed farm implements.
- Having done these, foresee the likely output, fix MSP for the crops produced and strengthen procurement machinery as wells as storage infrastructure.
- Assess post harvest infrastructure and competitiveness of the existing manpower to effectively handle the produce and add value to them. Since they are, by and large, not very sound, draw up a plan to first train the manpower and then infrastructure updating and/ or creating newer ones as the need be.
- Encourage the youths to adopt secondary agriculture covering the areas of seed, organic fertilizer/ pesticide production, start ups with farm implement manufacturing, food grading, packaging, branding and marketing thus providing locally the backstopping support need to tighten both the back end and forward end linkage chain as well as for creating the missing platform for non-farm earning and employment and also for doing away with the middlemen involved in supplying inferior inputs or taking away the major profit portion at the cost and labor of the farmers. Each penny so saved shall add to the income of the farmer.
- Take the advantage of GoI initiative for establishing 2 Primary markets in each district and 2 Secondary agricultural markets in each block followed by around 5-6 terminal markets across the state. Also plan for linking the state with e-NAM after a year or two.
- Skillfully empower the extension agents both for technology and its delivery technique as well as on market intelligence gathering so as to pave the way for regional market within the NE Region specially through the trading of niche area crops/ commodities of one state to plug the weakness of the other states in producing the same, ie., promote complimentary and supplementary agriculture trading within the region.
- Similar assessment and intervention identification for livestock/ poultry and fisheries sector either on Integrated Farming or on

independent farming mode as per the call of the resources and aptitude.

- Plan to develop the village community halls with electronic facilities, the facilities for custom hiring centers for farm machineries as well as with e-choupals.
- Explore the possibility of roping in private players in a partnership mode to translate the currently pursued CDR (Complex, Diverse and Resource Poor) form of agriculture to a semi-commercial to commercial mode.
- Pool 25 percent of CSR fund from the corporate sector for this cause and also involve NABARD like organizations.

After two years of doing the program in the villages suggested above, the other districts and villages will have to be covered in remaining 3 years. The target is achievable. We have committed man power and also the willing farmers to be the beneficiaries. What is needed is the convergence among the players implementing various government schemes. For example, agriculture department of the state is learnt to have been allocated Rs. 40 crore this year for carrying out demonstration under RKVY. This amount needs to be utilized for doubling farmers income together with the fund available under departments like Irrigation and soil conservation, social welfare, rural development etc. 10 percent fund from these and other related departments needs to be earmarked for this cause and a nodal department/ agency formed under the direct supervision of either the Agriculture Minister or the Chief Minister. We have to realize that lending a helping hand to the farming community who produces food for all of us, is much better than joining the two hands for prayers.

Diversifying Rice-based Farming System Through On-farm Resources Management for Enhancing Farmers' Income and Employment

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Introduction

The green revolution technologies were the corner stone of the past three decades. India has not only achieved self-sufficiency in food grain production but also have as much as 70 million tonnes (mt) in the buffer stock and 10mt. of rice and wheat for export. Such fast growth in agriculture production has led to several new challenges, making further growth possible only if these challenges are met appropriately and timely. Degradation of land and water resources, loss of plant biodiversity, shift of agricultural land for non-agricultural uses, decline in size of operational holdings, environmental pollution and resultant climate changes, fatigue in agricultural production (declining factor productivity) and widening gap between rich and poor are important post-green revolution issues threatening food security. Before green revolution, physical access to food was the most important food security challenge, economic access to food has now become the most important cause of under nutrition. In this millennium, ecological access to food may become the most important concern owing to the damage now being done to land, water, flora, fauna and the atmosphere. Notwithstanding the merits and demerits of current technologies, the time has come to convert weakness into strength, threads into opportunities, loss into savings and destruction (hazards) into development by adopting farming system research leading the nation to meet the food security challenges coming ahead. To exploit the benefit of science and technology for achieving consistent development in agriculture, better livelihood and socio-economic standard, it is indispensable to transform subsistence agriculture into a viable industry which would take care of the above challenges and constraints into active consideration. Obviously, the farming systems perspective to research is the most opportune, and perhaps the only pathway that can ensure food security under the constrained conditions. Considering these viewpoints i.e. shrinkage of agricultural land and operational holdings, change in food habit, geometrical population growth rate, farmers do not have any other option except to include some more enterprises like animal husbandry, bee keeping, fisheries, piggery etc. other than crop production, and to manage them as industry for augmenting house income, conservation of natural resources and food security in a diversified way. The significance of farming system could be visualized as under:

i. Balanced food production

After meeting the cereal requirements of burgeoning population of the country, time has come to endow with balances food demand of the entire Indian malnourished population. By following ICMR recommended dietary standard in 1990, the total consumption of milk, eggs and meats would be nearly doubled. The situations justify the need of farming system which has several components like dairying, poultry, goatary, fisheries etc. along with crop production. In this way, farming system would not only meet the food for but also cater the need of protein, fat, vitamins and minerals required for good health. Conjunction of horticulture and agro-forestry with cropping would ensure the seasonal access to fruits, fuel, fodder and fibre.

ii. Quality food basket

As per World Health Organization projection, the food demand in future will have more diversified food basket. As the living status is improved the requirement of cereals will be decreased and supplemented by other item viz. milk, egg, meat, fruit etc. The analysis further indicated the farming systems have potential to increase the protein production by integration of poultry, fish, pig and mushroom in cereal based cropping system, and soybean, sunflower and ginger in agro-horti. cropping system.

iii. Enhancing productivity and farm income

As the benefit: cost ratio and input use efficiencies have declined the farmers need more and more input to achieve the previously attained yield goals. The situation has so worsened that no farmer even in developed states of the country like Punjab and Haryana is happy to make investment in crop based agricultural system. If the expenditure made on crop based agriculture is repartitioned into different components of farming system as per capability of farmers, the net return, family labour earning and total income could be increased manifold.

iv. Employment generation

Since crop based agriculture is highly season specific and time bound, the intensity of labour requirement increases during sowing and harvesting time of crops. For rest of the time farmers remain idle if they do not have off-farm activities. This leisure time could be utilized effectively by adoption of farming system, which keeps the whole family busy throughout the year. The basic feature of farming system is to sustain the productivity, profitability and continuous employment generation by integration of various components.

v. Poverty alleviation

Farming system could be proved as effective tool in eliminating poverty as it provides higher income, regular employment, and balanced and quality food, besides improving soil health and mitigation of aberrant weather situation. The above factors finally increased purchasing power of farmers, which provides economic access to food.

vi. Effective recycling of resources

The farming system as a whole provides opportunity to make use of produce/waste materials of one component as input for another component, either at minimum cost or free of cost. Since the farming system involves integration of various farm enterprises, which otherwise dealt separately, the effective recycling of farm resources is possible by adoption of farming system research.

vii. Conservation of natural resources

Indiscriminate exploitation of natural resources without considering the carrying capacity and non-judicious use of agricultural input to fetch higher and higher production had generated a series of problems. Thus, Mahatma Gandhi's statement "Nature provides for everybody's need but not for everybody's greed" has to be given due consideration in exploitation of natural endowments. Adoption of farming systems helps in rational use of basic resources such as land, water and vegetation in such a way that it serves the objective of accelerated growth, employment, social justice and ecosystem protection.

Prevalent Indigenous farming systems viz; Zambo farming, Wet rice cultivation, Use of alder tree in cultivation, Rice cultivation of Apatani plateau and Bamboo drip irrigation, adopted in NEH region are one of the best example of conservation of natural resources and maintaining the ecological balance. Zambo farming system, which has a combination of forest, agriculture, and animal husbandary with well-bonded conservation base, reduces soil erosion by effective water resource management and protection of environment. Forest cover keeps off climatic disturbances and provides enough fuel and fodder. The alder tree has ability to fix atmospheric N, its roots possess soil binding capacity, and helps in sustaining the soil fertility. In this system each and every farmer take care of his own land with his or her skill and natural resources.

viii. Reducing risk factor

Indian agriculture is fully dependent on monsoon, which is quite erratic and fluctuating over a period of cropping season or from year to year. The single commodity based agriculture is always endangered due to natural hazards like floods, draught and epidemic diseases. As the farming system comprised of several farm enterprises like livestock, fisheries, poultry etc. in addition to cropping, it provides the opportunity to the farmers to have a 'basket of complementary options' for reducing the risk involved in single commodity based agriculture.

Diversification in agriculture

In agriculture, diversification essentially refers to a shift from one enterprise to another enterprise. Crop diversification is governed mostly by the price fluctuations in market, and inclusion of a new crop in production systems is indeed farmers' response to price signals. The farm enterprise diversification is adopted with a view to utilize the unexplored or little explored resources to raise the income. In the context of globalization, both kinds of diversification are necessary although the extent of diversification may vary at micro-level depending on farming situation, domestic market support, export possibilities and socio-economic conditions of the farmer. In post-green revolution periods area under rice and wheat increased tremendously on the expense of the area under coarse cereals and pulses. Now-a-days a farmer growing agricultural crops only started adoption of dairying, horticultural crops etc. depending on resources available and market demands. The research on diversification is expected to suggest the most remunerative and resource-conserving production system(s) by harnessing positive interactions of various enterprises after in-depth characterization of the farming situation. So, diversification in farming is becoming the most opportune system in the present day agriculture.

Nearly 50% farmers in India cultivate less than one ha of land holding and about 80% less than 2 ha. Nearly one-third population of the country is suffering from poverty and hidden hunger. Diversification into farming system mode in small holder farming appears promising to secure future food and nutritional security at the grass root level. There appears a strong case to relook the concept of traditional mixed farming practices and applying new advances of science made in the individual crop, commodities and enterprises for scientific integrated farming at small land holder level. Several experiments on farming system research in the country clearly showed enhanced nutrient and water use efficiency and profits when livestock, fisheries, poultry, piggery etc. were associated with crops. The system ensures better recycling of by products and residues of system components within the system to reduce dependence on fertilizers. Integration of farming system components focused on synergetic recycling of plant nutrients and *in-situ* management of greenhouse gases should be priority agenda for future nutrient management research. Multi-enterprise agriculture has also shown the potential to decrease cultivation cost by synergetic recycling of bi-products/residues of various components within the system and also a regular source of income and employment.

Diversification option for rice farmers:

Diversification of cropping systems is necessary to get higher yield and return, to maintain soil health, preserve environment and meet daily requirement of human and animals. Thus, not only the number of crops but the types of crops included in the cropping sequence are also important. For this, heavy reliance on cereal crops need to be shifted to other food crops like potato, vegetables, pulses and oilseeds. Inclusion of potato in rice-based crop sequence in West Bengal has become attractive because of high yield and remunerative price of potato (IPCP, 1999), and Raju and Reddy (2000) reported that inclusion of legume increases soil fertility status. Parihar *et al.* (1999) reported that energy output of major products was highest in the rice-groundnut system. Agricultural diversification towards high-value crops can potentially increase farm incomes, especially in a country like India, where demand for high-value food products has been increasing more quickly than that for staple crops. So, diversification has been envisaged as a new strategy for enhancing and stabilizing productivity, making Indian agriculture export competitive and increasing net farm income and economic security and towards achieving the sustainable agriculture development. Hence it was felt necessary to work out location-specific cropping system which can utilize resources judiciously to maximize return and protect the environment.

Not only crop diversification, enterprise diversification is also another option. Many rice farmers in coastal and in low-lying areas have diversified their farm enterprises to minimize risk. Rice (*Oryza sativa* L.) is a semi aquatic plant, whereas fish and prawn are aquatic in nature. Therefore, integration of aquaculture with rice farming in flooded paddy augments farm output and also benefits rice by improving its environment. This system was found to be economically beneficial, besides reducing pest infestation. Further, rice-fish/ prawn-horticulture/silviculture systems provided more returns and help in maintaining ecological balance. In a rice-fish integrated farming system, a gross return of Rs. 44,382 and net returns of Rs.11,226 was obtained from 0.5 ha area (Rautaray *et al.*, 2005), besides generating employment of around 350 man-days (Table 1). The total expenditure for the first year including cost for farm construction was Rs. 33,156. Compared to this, the income from the same field through traditional rice farming (only one crop) was Rs. 4,000. Adoption of this rice-fish farming thus provided a 2.8 –fold-higher income in the first year, which is again expected to increase in the subsequent years.

Table1. Return on expenditure from different components in first year from rice-fish system.

Items/Crops	Operational cost including labour (Rs.)	Gross returns (Rs.)	Net returns (Rs.)
Farm construction	6,000*	-	-
Rice	17,106	25,387	8,281
Fish	8,650	17,180	8,530
Vegrtables and horticulture crops	1,400	1,825	425
Total	33,156	44,382	11,226

*10% of the cost of construction + interest on total cost is taken as the depreciation cost.

Different types of rice-fish integration:

Rice-fish farming systems can be broadly classified as "capture" or "culture" systems, depending on the origin of the fish stock. In the capture system, wild fish enter the rice fields from adjacent water-bodies and grow and reproduce in the flooded fields. In the culture system, on the other hand, rice fields are deliberately stocked with fish either simultaneously or alternately with the rice crop. They are briefly described below:

a) Rice-fish capture

The earliest and still most widely practiced system involves the uncontrolled entry of fish and other aquatic organisms into the rice field and this method is called the captural system of rice-fish culture. This can only be considered a rice-fish culture system if the fish are prevented from leaving once they have entered the rice field. In the system, the organisms often depend wholly on what feed is available naturally in the field, although it is not uncommon for farmers to provide some type of supplementary feeds. This system is often practiced in rainfed areas and plays an important role in many rice-producing countries, for example in Thailand where rainfed areas constitute 86% of the country's rice area, the transition from a pure capture system and a capture-based culture system is gradual and was described as a continuum.

b) Rice-fish culture

The stocking and growing of fish in a rice field is basically an extensive aquaculture system that mainly relies on the natural food in the field. The benefits of rice-fish culture as a low investment entry-level technology for resource poor farmers was reported by many scientists. On- farm resources are cheap, readily available feedstuffs are often provided as supplementary feeds, particularly during the early part of the growing cycle. For the management of the rice crop, compromises are made with respect to the application of fertilizer, which is done judiciously. Fish-rice culture may be concurrent or rotational. Fish stocking in these systems may range from fewer than 500 to 5000 fish/ha in high intensity systems, with about 3000 fish/ha being optimal.

c) Rotational culture

During the season of flooding, the land is used for fish culture. In the dry season, the areas reverted again to individual management of modern rice varieties. The seasonally flooded areas are also managed by group and benefits are also shared by the group involved. Raising fish during the fallow period or as a winter is practiced to make use of the rice field when it otherwise would not be used. In China it is practiced but does not seem to be as widely practiced as concurrent culture.

d) Rice and fish with livestock

Carrying the concept of integration one step further livestock rearing may also be integrated with rice-fish systems. This has been tried in many areas but is not as common as the integration of livestock with pond culture. The most common form of integration is the rice-fish-duck farming. Integrated livestock fish-farming, as commonly defined, includes the direct use of fresh livestock manure in fish production. The livestock may be confined over the fishpond and wastes drop continuously through slats into the pond or the livestock may be housed adjacent to the pond from where wastes can be easily washed down or scraped into the pond.

e) Rice-duck system:

Rice-duck farming system is a traditional practice in some of the Asian countries. Duck farming is closely associated with wet land rice farming. It is traditional practice in south India, Philippines, Indonesia, Thailand and Vietnam. The swampy areas with canals, ponds and rice field provide optimum condition and environment for ducks. The ducks enhanced the rice yield, reduce the labour cost, maintain the soil and water for healthy growth of rice crops. There is additional income from the sale of duck eggs and meat. It provides cheap animal protein and balance diet. The small land holders are benefited by integration of ducks in rice farming systems and their number is increased day-by-day. The duck integration in rice field increases the rice yield by reducing weed growth, insect population, increasing soil physical properties with better root system and tillering. It increases the dissolved oxygen content in rice field. However, ducks in rice farming reduces the greenhouse effect; prevent the release of methane gas, important to check global warming.

f) Rice-fish+azolla system:

The dual culture method of growing *Azolla* with rice has gained widespread adaptability because standing water is available in rice field from seedling to panicle maturity in lowland rice fields and is effectively used for *Azolla* as biofertilizer. Azolla can accumulate up to 2 to 4 kg of nitrogen/ha/day. The use of Azolla has been a part of rice cultivation in Vietnam and China for centuries and its performance was tested in other rice growing countries, including India. Fish culture in rice fields loosens the soil as a result of their free movement in water body and thus aerating the soil, enhances the decomposition of organic matter and promotes release of nutrients from soil. The excreta of fish directly fertilize the water in rice fields leading to increase in utilizable source of N to the rice crop. Integration of allied components like *Azolla* + fish with rice in lowland farming could provide wider scope for bio-resources recycling.

Other forms of rice-based farming systems:

Rice-poultry-fish-mushroom integration on-station studies were conducted between 1987-1992 taking the marginal farmers' situations i.e. problems and opportunities in to considerations in Tamil Nadu. Economic analysis of the system under lowland ecosystem revealed that a net profit of Rs.11,755/year was obtained from rice-poultry-fish-mushroom integrated farming system (IFS) in 0.4 ha area while in conventional cropping system (CCS) with rice-rice-green manure/pulses gave a net income of Rs.6,334/year from the same area (Table 2). IFS increased the net income and employment from the small farm holding and providing balance diet for the resource poor farmers.

Table 2: Economics of rice based farming systems for a marginal farmer (0.4 ha) under low land ecosystem in Tamil Nadu (mean of 1987-1992)

Component	Expenditure (Rs.)	Gross return (Rs.)	Net return (Rs.)
Integrated Farming System			
Crop	11,398	19,076	7,678
Poultry	1,944	2,861	917
Fishery	1,486	3,568	2,082
Mushroom	5,078	6,156	1,078
Total	**19,906**	**31,661**	**11,755**
Conventional cropping system (CCS)	**7,202**	**13,536**	**6,334**

Source: Rangaswamy *et al.* (1996)

Another such rice-based integrated farming system study revealed that among the different farming enterprises compared for integration along with lowland transplanted rice, viz. fish culture, rabbit rearing, and poultry rearing performed significantly superior. Positive interactions among these enterprises resulted in higher crop yield, economic indices and soil fertility status. The highest net returns of Rs. 1,55,920/ha and Rs. 2,28,090/ha during the first and second season, respectively were obtained with integrated rice+fish+poultry farming systems. The same also recorded the highest grain yield of rice (5.67 tonnes/ha and 5.25 tonnes/ha during first and second season respectively). The highest post-harvest soil nutrient status with regard to N, P, and K was also observed with rice+fishculture+poultry farming system. The rice-based integrated farming system comprising of crop components (Rice-Pea-Okra and Sorghum-Berseem-Maize), dairy, poultry and fishery was the most suitable and efficient farming system model giving the highest system productivity and net return under irrigated agro-ecosystem of eastern Uttar Pradesh. This model generated significantly higher levels of employment than the rice-wheat system only. Study conducted in farmer's field in Ludhiana revealed that rice based integrated farming systems involving rice-wheat + poultry + dairy + piggery + poplar + fishery produced significantly higher rice equivalent yield and net return (Rs. 73,973/ha) when compared with conventional practice of rice-wheat, where a return of Rs. 53,221 was obtained, Gill *et al.*, (2005). Integrated rice-based farming system also generated an additional employment of 48-man-days/ha was recorded in comparison to rice-wheat.

Rice-based farming system to the improvement of livelihoods of farmers:

The rice-based farming system contributes to the livelihoods of the poor through improve food supply, employment and income. Many small-scale farmers have small land holdings in areas of complex, diverse and risk prone agriculture in mainly rain fed and undulating land on the fringes of lowlands or in uplands. The immediate beneficiaries of the production of fish and often improved rice yield in rice-fish farming are the farmers who adopt the technology. Models developed using linear programming techniques on 2.3 ha farm in Guimba, Nueva Ecija, Philippines showed that the adoption of rice-fish farming technology can generate an additional 23% more farm income by raising fish as well rice. This increases to 91% if the entire 2.3 ha area is stocked with fish, even if rice production remains constant and farm requirements for cash and labour increased by 22% and 17%, respectively (Ahmed *et al.*, 1992). In rice-based farming system, risk is reduced due to diversification of system with low risk-enterprises like fish and vegetable cultivation (Behera *et al.*, 2008). Rice-fish farming system not only increases the farm income, but also gives nutritional security to the family of the rural farmers through providing foods. Further the system also ensures integration of other compatible agricultural and animal components suiting to the regional needs and increasing the farm income.

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Contribution of ICAR RC for NEH Region for Regional Agricultural Development

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Dr. M. S. Swaminathan "father of green revolution in India" and then Director General of ICAR emphasized a separate research unit to carry out research and development of north eastern hill region of the country during a seminar way back in 1973. This brain child was further shaped and ICAR Research Complex for NEH Region, Umiam came into existence on 09th January, 1975 and Dr. (late) D. N. Borthakur joined as its first Project-Director. The dynamic leadership of Dr. (late) Borthakur and able guidance of subsequent directors sculpt the institute and become the iconic in the field of agriculture in the region. The institute has been constantly endeavoring to develop location specific technologies through its ten divisions at the headquarter at Umiam, Meghalaya and its six regional centers at the six hill states of the north eastern region. Through its 19 KVKs distributed in different states, the institute is delivering its technologies to a large number of farmers in the remote localities. The institute has been disseminating modern technologies for livelihood and nutritional security in the region that include truthfully labeled seeds, quality planting materials, improved animal breeds, poultry and fish seeds including proto-type implements and tools suitable for hill agriculture, soil health testing kits, diagnostic kits for animal parasites, diseases and critical inputs. About 15 AICRPS, 5 network and 15 collaborative projects are in operation. The institute has strong linkage with other ICAR institutes and universities, international organizations like IRRI, ICRISAT, ILRI and IWMI. The institute also collaborates with government sponsored agencies like NERCOMP, MRDS, NABARD and IFAD; several NGOs and farmer bodies and co-operative societies for technology dissemination.

Institute since its inception has done many basic, strategic and applied research specific to the farming problems of the NEH Region. Development of 32 location specific farming system and agroforestry models including viable alternatives to shifting cultivation, released 56 crop varieties including 37 rice varieties, identified high yielding livestock and fish species/breeds, package of practices for field and horticultural crops including production technology for 32 crops on cropping system basis, livestock and fish farming practices, crop and livestock production measures etc. are some of the salient research achievements of the institute. Discipline wise contribution in the last forty years for the agricultural development in the region is explained below.

Plant Breeding and Biotechnology

The discipline has developed a total of 10 varieties of rice and five composite varieties of maize using indigenous germplasm for different hill ecology and also firstly reported on plant regeneration from mesophyll protoplast of rice. Apart from that, using asymmetric protoplast fusion, transfer of wild abortive cytoplasmic male sterility to the nuclear background of RCPL 1-2C (an advanced breeding line that has served as maintainer of the cytoplasm) has also been achieved by the discipline.

Agronomy

The gradual shift in research priorities has been observed in the discipline as during the initial years of the institute the emphasis of the discipline were on developing low input and best management practices of field crops, suitable establishment methods, weed control measures, multiple cropping, water management in different cropping systems and finding a viable alternative farming system of jhum farming to natural farming, organic farming, integrated farming system, conservation agriculture etc. There are many technologies such as; raised and sunken bed technology for crop diversification and productivity enhancement, No-till (NT) production of pea, lentil and rapeseed in rice fallow for enhancing cropping intensity and productivity, modified System of Rice Intensification fir higher productivity, maize-french bean/ black gram/ green gram/ rapeseed cropping system, land use model for sustainable production and climate resilience in Eastern Himalayas, improved rice cultivation techniques in jhum field for enhancing productivity and sustaining soil health, Integrated Organic Farming System model for valley land, micro-watershed farming system model for natural resource conservation etc. developed by the discipline.

Agroforestry

Considering the importance of Agroforestry in agricultural system the discipline has contributed significantly in the last forty years by developing different technologies such as; MPT based agroforestry systems for improving productivity and sustainability of slopping land, three tier agroforestry system for the slopping land of the mid altitudes of the NEH region, agri-horti system for improving productivity and sustainability of slopping land, sericulture based agroforestry system, intensive integrated farming (IIFS) for utilization and enhancing production potential of lowland valley areas. The discipline has also contribute significantly in research such as development of High Yielding variety of *Mucuna pruriens* with higher L-DOPA and rust resistance, agroforestry system under hill ecosystem for round the year flow of income, soil quality index for landuse systems, decision support system on medicinal plants in Meghalaya etc.

Soil Science

The major areas of research in the soil science discipline have been; acid soil management for enhancing crop productivity, integrated nutrient management for managing soil health, assessment of soil qualities under various nutrient management and land use system, soil and water conservation and nutrient dynamics under impending climate change. The major research achievements of the division includes; development of soil health test kit, finding easily adoptable and cost effective method of lime application (furrow application) for soil acidity management, development of compost preparation techniques from locally available bio-resources, establishment of moisture conservation techniques, finding liming values of organic manures, development of alternative methods of nutrients application for improving nutrient efficiency, refinement of soil test methods and soil quality assessment under various land use systems.

Water Management

The water management discipline has a basket of technologies and research achievements to showcase their significance. The important ones are; micro rain water harvesting structures *(Jalkund)*, in-situ soil moisture conservation in maize-mustard cropping system, micro irrigation for high value crops (strawberry and cauliflower), resource conservation practices in maize-mustard cropping system in terrace land situation etc. Apart from that the discipline is also involved in participatory demonstration conducted in farmer's field such as; pea nad capsicum cultivation in rice fallow for enhancing water productivity and livelihood of hill farmers, designing economic and efficient water harvesting structure, technique for improving water productivity and assessing water quality for creation of livelihood opportunities for the farmers of NEH region etc.

Horticulture

The north eastern states have the strategic advantage for horticultural crops. Considering its importance in the economy of farming community the discipline has developed 6 tomato varieties, 2 brinjal varieties, 1 turmeric variety, 1 papaya variety, 1 pineapple variety and released by the institute for the North East region. Apart from that some other technologies such as; standardization of propagation technique for Khasi Mandarin, standardization of rootstock for Khasi Mandarin in NEH region, improvement of self life of peach,off-season production under low tunnels, self life extension of strawberry fruits, vegetative propagation techniques for Sohiong (*Prunus nepalensis*), standardization of leaf to fruit ratio (LFR) for yield and quality traits in peach, guava production under meadow orchard planting system for mid hills altitude, shelf life extension for Sohshang using MA packaging, off season production of tomato in polyhouse, vegetative propagation in chow-chow etc.

Crop protection

The division of crop protection contributed immensely in the various research activities since the inception of the institute. Important and significant technologies developed by the division are; fruit fly trap RC-1, complete mitochondrial genome sequence of a phytophagous ladybird beetle *Henosepilachna pusillanima* (Mulsant), IPM technology for the management of brinjal fruit and shoot borer in brinjal, mass rearing technique of parasitoid wasp, *hyposoter ebeninus* Gravenhorst, insect generic stock: a repository of insects from north eastern Himalaya, low cost specialized multi-utility rearing cage for larval nad pupal parasitoids and their factitious hosts, low cost mushroom house, multiplication technology of biocontrol agent *Trichoderma* sp., economical way for managing early leaf spot disease in groundnut, management of scab and powdery mildew disease in Khasi Mandarin, management of foot rot disease in Khasi Mandarin etc.

Animal production

Animal production division has a key role in developing technologies in hill eco-system for enhancing income and livelihood of the farmers. The upgraded pig developed by the division is one of the most popular and widely accepted technology by the framers, beside broiler rabbit production, pig housing model for hill eco-system, complete feed-block, artificial insemination in pig, low cost pig feed and value added bristle pig products. The division has developed a new pig variety “Lumsniang” by crossing Khasi local pig (Niang Megha) with Hampshire and released, low cost climate resilient environment –affinitive pigpen model, in-house methodology for bristle processing in washing/cleaning/shoe brush, turkey and quail farming, portable compact feed block making device etc. The division has also filed a patent for low cost portable dummy sow with mating grunt voice system.

Animal health

The division of animal health is working toward monitoring the animal health status of the whole NEH region. Simultaneously, carrying forward the surveillance of zoonotic and food borne diseases in the region so as to minimize the spillover of animal diseases to human and vice versa. The division has been working through its various scientific disciplines of Veterinary Public Health, Veterinary Parasitology, Veterinary Microbiology and Veterinary Medicine carrying out works pertaining to the three major areas of the institute mandate – sero-survillance, clinical surveillance and diagnostic assay development. The services of the division are being rerularly utilized by the state governments, farmers and other related laboratories for identification and characterization of animal disease. This is apart from the research work being done under the broad thematic areas of Veterinary Public Health, zoonotic pathogen, food borne pathogen of food and animal origin, drug resistance profiling of pathogens covering all the parasitic, viral, bacterial diseases affecting livestock of the origin. During the last 42 years, the division was able to come out with several animal and zoonotic disease diagnostics; it has developed advanced diagnostic facility in the region and solved many mysteries of unknown outbreaks which tried to enter and establish in the region. The division has developed classical swine fever diagnostics and vaccine, mastitis detection kit etc.

Fisheries

Fish being the cheapest source of animal protein, can ensure the nutritional requirements and alleviate malnutrition in the region. Considering this need, for the past several years the major focus of this division has been dedicated to the promotion of hill aquaculture for meeting the food security and conservation of fish biodiversity of the region. The division of fisheries has introduced many new scientific techniques for enhancing the fish production in the region. Modern technologies like composite fish farming, polyculture and cage culture under intensive aquaculture, integrated fish farming with livestock as well as agricultural/horticultural crops, artificial induced breeding of carps and other fishes for enhancing the aquaculture production are some of the technologies introduced by the division. Not only in terms of production, the division has also taken up steps for conservation of endangered fish species in the region; several indigenous fishes like chocolate mahseer, pengba [*Osteobrama belangeri* Valenciennes)], etc. were identified and bred in captivity in the institute. The state fish of Manipur i.e. Pengba has also been reared, bred and ranched in the Umiam reservoir and cryopreservation of endangered chocolate mahseer is also performed for conservation of the gene pool of NEH region. In the past 3-4 years in order to meet the seed requirement in 05 hill states of the region, 12 number of FRP carp hatcheries (CIFA model) were established at farmer's field.

Agricultural Engineering

The division of agricultural engineering is mainly involved in developing and modifying implements, machine and tools for hill agriculture, reduce water scarcity faced by hill farmers and also to reduce soil erosion, provide processing technique of the locally available agricultural produce. The division has improved and modified watershed approach technologies for soil and water conservation in NEH region through various engineering approaches such as; Contour/graded bunds, bench terraces, contour trenches, half-moon terraces, grassed waterways, water harvesting ponds and drainage line treatments. Some other technologies such as plastic (agri film) of lining of water harvesting pond on hill slopes (*jalkund*), roof top water harvesting , cost effective terrace formation through bio-terracing, low cost bamboo frame polyhouse technology for terraced beds in hills, light weight and low cost plastic maize sheller for drudgery reduction, beehive briquette mould for small scale entrepreneurship by landless farmers, modified cono weeder for lowland paddy field, adjustable row maker for marking rows in seed bed, metallic tip dibbler for steep slopes, lond handle weeders, adjustable zero till furrow opener, light weight fruit harvester for hill orchard, modified hand operated winnower, portable pedal operated paddy thresher for hills, power tiller operated inclined plate planter, power paddy thresher cum cleaner, portable charring kiln etc. were also developed by the division for the benefit of hill farming community.

Social Science

The division is specifically focused in the dissemination of the technologies developed by the different disciplines of the institute through its outreach programs. To facilitate access to information and inputs and also to provide consultancy services, the ATIC was started under the aegis of the division. During the last five years, more than 12000 farmers have been benefitted through distribution of a total 444.82tons of seeds of various agricultural and horticultural crops and also generated a total sum of Rs. 2,75,752 from the sale of literature, viz. books, technical bulletin, folders, leaflets published by various centres of the institute. Apart from dissemination the division is also involved in the socio-economic research aspect in the region. In the last decades, the research focus has been mainly on working out the economics of emerging technology, assessing impact of agricultural research and technology, farming system analysis, institution and marketing arrangement, sector and policy analysis etc.

Conclusion

The institute has come a long way since its establishment and mile to cover further. During the journey it faces the contemporary challenges and accordingly acts on them. The challenge to secure the sustainable livelihood in the changing climatic scenario for the farmers of NEH region is well shouldered by the institute and subsequently orients their research priorities. The baton for research heritage of the pioneer agricultural scientist of the institute is now with the new generation scientists and they are fully versed with the responsibilities towards the agricultural development of NEH region. Now the time has come to work together in a multidisciplinary team to counteract the problems faced by the farmers for doubling their income.

Millets for Food and Nutritional Security in Changing Climate

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Millets are the oldest known foods to humans. They are the small-seeded cereals belonging to poaceae family to which all major cereals belong. 'Millets' is a collective term used to refer a diverse group of small-seeded annual C4 Panicoid grasses that are cultivated as food and fodder crops, primarily grown on poor and marginal lands in dry areas of temperate, subtropical and tropical regions across the globe (Dwivedi *et al.*, 2012; Lata *et al.*, 2013). In India, many kinds of millets are grown, which include sorghum, pearl millet, finger millet, foxtail millet, little millet, barnyard millet, proso millet and kodo millet (Table 1). Sorghum and pearl millet are considered as coarse millets; whereas the others group is known as small millets or minor millets. Millets grow well in dry zones/rain-fed areas under marginal conditions, poor soil fertility and limited moisture. Due to their short growing season, seed to seed cycle is completed in about 60-80 days. Moreover, they can be stored for years together without any damage to seeds. Most of the millets are highly nutritious, non-glutinous, non-acid forming and easily digestible foods. Being gluten free, individuals suffering from celiac disease can easily incorporate various millets in their diets. Millet ingestion helps in a slower release of glucose over a longer period of time; thus, due to low glycaemic index (GI), their habitual intake reduces the risk of diabetes mellitus. All millets are rich source of minerals like iron, calcium, zinc, magnesium, phosphorous and potassium. Finger millet is rich in calcium; and Pennisetum in iron. These also contain appreciable amounts of dietary fibre and various vitamins (β-Carotene, niacin, vitamin B_6 and folic acid); high amounts of lecithin are useful for strengthening the nervous system. Therefore, a regular consumption can help to overcome malnutrition among majority of our Indian population. These have often been called the *coarse grains*; however, due to their nutritional contributions, these are now being referred as "nutri cereals" or "nutri-millets".

Table 1. Cultivation of different millets in India

Name (Vernacular name)	Botanical name	States in which cultivated
Sorghum (*Jowar*)	*Sorghum bicolor*	Andhra Pradesh, Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Uttar Pradesh, Bihar.
Pearl millet (*Bajra*)	*Pennisetum typhoides*	Dry land areas of Haryana, Gujarat, Madhya Pradesh, Rajasthan, Maharashtra, Karnataka.
Finger millet (*Mandua, Ragi)*	*Eleusine corcana*	Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Uttaranchal.
Kodo millet *(Kodo)*	*Paspalum scrobiculatum*	Madhya Pradesh
Foxtail millet (*Kauni, Kangni*)	*Setaria italica*	Karnataka, Tamil Nadu, Andhra Pradesh.
Proso millet (*Cheena*)	*Panicum miliaceum*	Bihar, Andhra Pradesh.
Little millet (*Kutki*)	*Panicum sumaterense*	Orissa, Bihar, Madhya Pradesh, Tamil Nadu.
Barnyard millet (*Madira, Sawan, Jhingora*)	*Echinochloa frumentacea*	Uttaranchal, Maharashtra.

Millet offers numerous advantages when compared with major cereals. These include: 1) Ecological advantages e.g. suitable to organic agriculture practices, eco-friendly nature; 2) Agronomic advantages e.g. highly adapted to low rainfall conditions, able to withstand fairly long dry spells, recover fast after delayed rain, root system efficient in soil moisture extraction, sustainable but modest yield under low management conditions in marginal areas, negligible pest and disease problems; and 3) Socio-economic advantages such as very rich food cultural traditions, comparatively cheaper grains, longer storability of grain, good quality fodder (Padulosi et al., 2009).

Production of millets

Though millets rank sixth in world grain production after rice, wheat, maize, barley and sorghum, they are usually considered as a subsistence product and more often than not looked upon as a poor man's crop (Dwivedi *et al.*, 2012; Lata *et al.*, 2013). Noteworthy, India ranks first in global millet production with an annual production of ~11 million tonnes in 2013 (FAOSTAT, 2014; http://faostat.fao.org/site/567/Desktop Default.aspx?PageID=567#ancor). Despite their significance, millets have largely been an under researched crop commodity as compared to other staple cereals. Since millets are grown in low-input, rain-fed agriculture system, they tend to suffer from drought spells due to scarce, untimely and irregular rainfall that ultimately becomes major constraint for crop yield. Besides drought, soil salinity and high temperature are another major abiotic stress factors that severely affect the crop.

Nutritional significance of millets

Micronutrient deficiencies afflict more than two billion individuals, or one in three people, globally. Such deficiencies occur when intake and absorption of vitamins and minerals are too low to sustain good health and development. Over the last 50 years, agricultural research for developing countries has increased production and availability of calorically dense staple crops, but the production of micronutrient-rich non-staples, such as vegetables, pulses and animal products, has not increased in equal measure. Millets are highly nutritious, being rich source of proteins, vitamins, and minerals. About 80% of millet grains are used for food, while the rest is used as animal fodder and in brewing industry for alcoholic products (Vinoth and Ravindhran, 2017). The grains are ground into flour and consumed as cakes or porridges. Millets are recommended for well-being of infants, lactating mothers, elderly, and convalescents. The grains release sugar slowly into the blood stream and thus considered "gluten-free" (Taylor and Emmambux, 2008). With high fiber and protein content, millets are preferred as dietary foods for people with diabetes and cardiovascular diseases (Kumar et al., 2016; Sharma et al., 2017; Muthamilarasan et al., 2016). In addition, they contain health promoting phenolic acids and flavonoids, that play a vital role in combating free-radical mediated oxidative stress and in lowering blood glucose levels (Kunyanga et al., 2012). Pearl millet is rich in Fe, Zn, and lysine (17–65 mg/gofprotein) compared to other millets (McDonough et al., 2000). Foxtail millet contains a high amount of protein(11%) and fat (4%).The protein fractions are represented by albumins and globulins (13%), prolamins (39.4%), and glutelins (9.9%). It is thus recommended as an ideal food for diabetics. It also contains significant amounts of potential antioxidants like phenols, phenolic acids, and carotenoids (Saleh et al., 2013; Zhang and Liu, 2015). Finger millet grains contain higher levels of minerals like Ca, Mg, and K (Sood et al., 2017; Saleh et al., 2013; Devi et al., 2014). It also has high levels of amino acids like methionine, lysine and tryptophan (Bhatt et al., 2011), and polyphenols (Chandrasekara and Shahidi, 2010; Devi et al., 2014). Proso millet contains the highest amount of proteins (12.5%) while barnyard millet is the richest source of crude fiber (13.6%) and Fe (186mg/kg dry matter) (Saleh et al., 2013). Barnyard millet grains possess other functional constituents' viz. g-amino butyric acid (GABA) and b-glucan, used as antioxidants and in reducing blood lipid levels (Kofuji et al., 2012). With lowest carbohydrate content among the millets, barnyard millet is recommended as an ideal food for typeII diabetics (Ugare et al., 2011). The proximate composition along with mineral elements composition in different millets in comparison to major cereal grains is presented in Table 2.

Millets in Climate Change and sustainable agriculture

The major strategic importance of millets with regard to climate change is their short life cycle, a trait which is very important for risk avoidance under

Table 1. Nutritional profile of different millets in comparison to major cereals (@ 12% moisture; per 100g edible portion)

	Finger millet[a,b,c]	Barnyard millet (dehulled)[b,c]	Foxtail millet (dehulled)[a,b,c]	Proso millet (dehulled)[a,b,c]	Little millet (dehulled)[b,c]	Kodo millet (dehulled)[b,c]	Sorghum[b,c,d]	Pearl millet[a,b,c]	Maize[b,c]	Rice brown[b,c,d]	Wheat[a,b,c]	Barley[b,c]	Oat[b,c,d]	Rye[c]
Proximate composition														
Protein	7.7	11	11.2	12.5	9.7	9.8	10.4	11.6	9.2	7.9	11.6	11.5	17.1	13.4
Fat	1.5	3.9	4	3.5	5.2	3.6	3.1	5.0	4.6	2.7	2	2.2	6.4	1.8
Crude Fibre	3.6	13.6	6.7	5.2	7.6	5.2	2	2.3	2.8	1	2	5.6	11.3	2.1
Carbohydrate (g)	72.6	55	63.2	63.8	60.9	66.6	70.7	67.5	73	76	71	58.5	52.8	68.3
Energy (Kcal)	336	300	351	354	329	353	329	361	358	362	348	352	389-	-
Total dietary fiber (%)	19.1	22	19.11	8.5	-	37.8	11.8	11.3	12.8	3.7	12.1	15.4	12.5	16.1
Minerals and trace elements														
Ca (mg/100g)	350	22	10	10	17	10	40	10	30	20	40	40	110	50
P (mg/100g)	283	267	310	150	220	320	350	350	290	120	350	560	380	360
K (mg/100g)	408	-	270	210	-	170	380	440	370	100	360	500	470	470
Na (mg/100g)	11	-	10	10	-	10	50	10	30	3	40	20	20	10
Mg(mg/100g)	137	39	130	120	139	130	190	130	140	30	144	140	130	110
Fe (mg/100g)	3.9	5	3.3	3.3	9.3	7	5	7.5	3	1.9	4	3.7	6.2	3.8
Mn(mg/100g)	5.94	0.96	2.2	1.8	0.7	1.1	1.6	1.8	0.5	1.2	4	1.9	4.5	5.8
Mb(mg/100g)	0.102	-	0.7	-	-	-	0.039	0.069	-	-	0.051	-	-	-
Zn (mg/100g)	2.3	3	2.2	1.8	3.7	0.7	1.5	2.9	2	1	3.1	2.4	3.7	3.2
Vitamins														
Thiamine (mg)	0.42	0.33	0.48	0.63	0.3	0.32	0.46	0.38	0.38	0.07	0.57	0.44	0.77	0.69
Riboflavin (mg)	0.19	0.1	0.12	0.22	0.09	0.05	0.15	0.22	0.14	0.03	0.12	0.15	0.14	0.26
Niacin (mg)	1.1	-	3.2	2.3	-	-	3.7	2.3		4.3	5.5	4.6	0.96	-
Total folic acid (µg)	18.3	-	15	-	-	-	20	45.5	-	20	36.6	23	56	-
Vitamin E (mg)	22		-	-	-	-	0.5	-	1.9	0.90-2.50	-	0.02	-	-
Phenolic compounds														
Total phenol (mg/100g)	102	-	106	-	-	368	43.1	51.4	2.91	2.51	20.5	16.4	1.2	13.2

[a]Gopalan et al.[20]; [b]FAO[50]; [c]Saldivar[51]; [d]USDA National Nutrient Database for Standard Reference, Release 28[52]

rainfed farming. Moreover, they have efficient root system for extracting water deeper from soil giving a comparative advantage of successful cultivation with scarce water/low rainfall. Their ability to offer a modest yield under marginal farming conditions, poor soil and low or no input, has made them attractive crop option in subsistence agriculture. This adaptive feature is particularly pronounced in some of the minor millets like foxtail millet and barnyard millet, which are fastest growing of all millets. Foxtail millet and barnyard millet produce a crop in six weeks and considered most resilient species among millets. Millets provide food, feed and fodder under harsh growing conditions of low rainfall and steep slopes. The deployment of plant genetic resources in risk coping strategies has been practiced by farmers for centuries in their traditional production systems. With regard to the use of minor millets in these strategies, interesting examples are seen in the hilly regions of the country.

Breeding methods in small millets

Due to small floret size of finger millet and barnyard millet, emasculation and hybridization is cumbersome. The contact method of hybridization is, therefore, an easy choice for breeders (Ravikumar, 1988). In the contact method the panicles at appropriate hybridization stage are tied together by intertwining the fingers of male panicle inside the female panicle. Only very few true hybrid seeds are produced in this method, consequently, all the seeds from female panicles need to be grown for identification of hybrid plants in the field. Another method, hot water emasculation (Raj et al., 1984) is a better alternative for hybridization in finger millet. In this method, the female panicles at appropriate stage are immersed in hot water at 48ºC for five minutes. Treated and air dried panicles are tied with male panicle in the same fashion as is done in contact method. In this method only few seeds set in the female panicle, most of which give rise to true hybrid plants. This saves both time and resources.

Since small millets are grown under diverse situation in the hills, development of varieties with wider adaptability is of utmost importance (Sood et al., 2015). In order to achieve these objectives, emphasis has been laid on recombination breeding followed by pedigree method of breeding to combine earliness with high grain and fodder yield, coupled with disease resistance. ICAR-VPKAS, Almora has been an active breeding center for these crops and has developed 11 and 6 varieties each of finger millet and barnyard millet, respectively, till date.

White grain finger millet breeding for hills

White grain finger millet genotypes has become a thrust area in finger millet breeding due to increased demand of non-glutinous food products and lesser acceptability of brown grained finger millet. Demand for finger millet grains has picked up in the urban areas and baking industry in the recent times due to high fibre and other health benefits associated with its consumption. However, the dark colour of grains has been the major hindrance for its acceptability in baking and food industry. Although preferred by baking industry, the yield potentiality of available white grain genotypes is significantly lower than the adapted brown grain varieties. In addition, the white grained finger millet genotypes bred in tropical conditions are unsuitable for hills due to late maturity. The crop growth period in hills is shorter and farmers prefer only early and medium maturity duration (90-110 days) genotypes. Therefore, ICAR-VPKAS, Almora started working on the development of early maturing blast resistant white grain finger millet varieties through extensive hybridization between brown grain adapted varieties of hill region and late maturing white grain types of tropical conditions. The efforts have resulted in the identification of first white grain finger millet genotype of ICAR-VPKAS for Uttarakhand hills in the year 2017.

Genomics and omics advancements in millets

Until recently, model plants such as *Arabidopsis* and rice were the focal point of research pertaining to studies on plant stress responses, while orphan crops like millets lagged far behind. However among millets foxtail millet, pearl millet, and to lesser extent finger millet have lately started gaining some importance among the research community wherein ‘omics’ have played an important role apart from conventional plant breeding. Since large genome size and polyploidy hindered the basic goal to unravel the nutritional traits and abiotic stress tolerance mechanisms in these naturally stress tolerant crops, recent progress in this area has been significantly enhanced by the development of foxtail millet as a model system to investigate evolution, physiology and the genetics of stress tolerance as well as nutritional importance in millets. Foxtail millet has been the obvious choice for model millet crop owing to its small genome size, diploidy (2n=2x=18), self pollination, short generation time and availability of efficient transformation platform (Lata et al., 2013). Powerful genetic and genomic tools such as isolation of expressed sequence tags (ESTs), genome sequencing, genetic and physical mapping, comparative mapping etc. have been thus established for the molecular genetic studies in millet crops (Dwivedi et al., 2012; Lata et al., 2013; Muthamilarasan and Prasad, 2014). The foxtail millet genome sequence and the high degree of synteny between foxtail millet and switch grass (*Panicum virgatum*), a bioenergy crop have a potential to facilitate genetic and genomic studies in related Panicoid crops (Lata et al., 2013; Lata and Prasad, 2013). Genetic maps and molecular markers also help in comparative mapping and synteny studies in crop plants, for example one of the recent studies have shown the synteny between pearl millet and foxtail millet chromosomes along with those of other grasses. However discovery of DNA markers and construction of genetic linkage maps in millets have lagged behind other cereal crops such as rice, wheat and maize (Dwivedi et al., 2012). Among millets, mainly foxtail millet, pearl millet, finger millet, job's tear (*Coix lacrymajobi*) and tef (*Eragrotis tef*) have been investigated for development of genetic and genomic resources (Dwivedi et al., 2012; Babu et al., 2014; Sood et al., 2016).

Value addition: an avenue for enhancing the income of millet growers

A variety of foods from the small millets are traditionally prepared and consumed, over the centuries, in Indian subcontinent, Africa and Central America. Majority of these products are made from flour prepared either from the whole grain or from partially decorticated grains. The knowledge base on the millet grain quality, processing and value addition is now increasing with recent R&D work across the world. ICAR-VPKAS, Almora has developed the technology for making biscuits of finger millet flour. The biscuits made of finger millet flour were found to have higher calcium, iron, zinc and dietary fibre in comparison to wheat biscuits. The technology has been commercialized. In Himalayan region of India and Nepal, brown coloured varieties are predominantly grown and consumed either in the form of unleavened bread, porridge, malt, popped grains and fermented beverage. In Uttarakhand hills of India, finger millet grains are mixed with dried bark pieces of gethi tree (*Boehmeria regulosa*) and then crushed to flour (Khulbe et al., 2014) to provide gluten characteristics to finger millet flour and enhance the roti making quality. Gethi is commonly found in Uttarakhand mid hills and its bark has medicinal value as well as rich in micronutrients along with high viscosity. The bark has been tested in different gluten lacking millets and psedu-cereal crops and results were similar as observed with finger millet. This indigenous knowledge is prevalent in Uttarakhand hills from time immorial and still in use but with the reduction in usage of finger millet as food crop the young generation is unaware of this information.

Summary

Millets are important crops in the climate change era. Due to wide adaptability and availability of diverse germplasm in these crops, they promise to be highly climate resilient crops. Moreover, these crops have excellent nutritional value. Development of improved varieties in these crops has resulted in high yields in these crops and genomics advancements have led to the identification of novel genomic resources in some of these crops. Although the area under these crops is much less than the major cereal crops, there is an increasing recognition of their favourable nutrient composition and utility as health food, in the context of increasing life style diseases as well as climate resilient future crops. Thus, apart from their traditional role as a staple for the poor in the marginal agricultural regions, they are gaining a new role as nutritious healthy food crops for the urban high income people and important genetic resources for food and nutritional security in the era of climate change.

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Vision and Goal of ICAR-ATARI, Guwahati for Regional Development

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ICAR-ATARI, Zone-VI, Guwahati
*** ICAR RC for NEH Region, Umiam**

Lab-to land programme, the flagship project of ICAR was launched on 1979 for the benefit of 50,000 farm families across the country. Zonal Coordinating Units (ZCUs) were created by ICAR for the effective implementation of the project. Further, the no. of KVKs has also been increased so, for efficient management of them the ZCUs have been further upgraded to Zonal Project Directorate (ZPD). Recently, the research component has also been added in the mandate of ZPDs and so, renamed as Agricultural Technology Application Research Institute (ATARI) from August 11, 2015. Presently, the numbers of KVKs are more than 600 and it became difficult to manage them by the erstwhile 8 ATARIs. So, in the XIIth five year plan, the Government has decided to form three more ATARIs at Patna, Pune and Guwahati. Subsequently, the foundation stone for the ICAR-Agricultural Technology Application Research Institute (ATARI), Zone-VI, Guwahati was laid by Hon'ble Union Minister of Agriculture & Farmers Welfare, Shri Radah Mohan Singh at ICAR-CPCRI, Regional centre, Kahikuchi on 14th February, 2016. ICAR - ATARI, Zone-VI, Guwahati with its headquarters at Kahikuchi, Assam.

The institute is primarily responsible for monitoring and reviewing the technology assessment, refinement, demonstration, training programmes and other extension activities conducted by KVKs in three states of north eastern region *viz.*, Arunachal Pradesh, Assam & Sikkim. Apart from that, the institute is also engaged in providing guidance to the KVKs to accomplish its technical activities, ensuring flow and access of technologies to the KVKs, enabling the Directorates of Extension Education of SAU in the region to oversee the activities of KVKs. The ICAR-ATARI, Zone-VI also takes up need based Human Resource Development (HRD) programmes for KVK staff with adequate financial support, liaison with different stakeholders and other line departments in the region.

Socio-Eco-Geographic scenario of the region under ICAR-ATARI, Guwahati

The ICAR-ATARI, Guwahati is managing the KVKs of three states of north eastern region *viz.*, Arunachal Pradesh, Assam & Sikkim which includes 43 KVKs (14 from Arunachal Pradesh, 25 from Assam and 4 from Sikkim). The region has a total geographical area of 169277 Km^2 which is nearly 1.72% of the total area of the country with around thirty three million population. Assam has the highest plain area which accounts of about 84.44% of its total geographical area. Net sown area is highest in Assam (34.12%) whereas the Arunachal Pradesh has lowest net sown area in the entire north eastern region. The soil of the region is acidic to strongly acidic in reaction. The low pH of the soil is basically due to the leaching of the bases under influence of high rainfall. The soils are, however, rich in organic matter. The depth of the soil varies from shallow in incept soils to very deep in alluvial soils. The region, by and large, is characterized by fragility, marginality, inaccessibility, cultural heterogeneity, ethnicity and rich biodiversity. The society is agrarian and depends on agriculture and allied sector for livelihood and other support. Agricultural production system is, by and large, of CDR type. Although the landholding appears to be higher, the entire holding cannot be used for agricultural purposes due to topographical disadvantages. Fertilizer consumption in the region is also very low as low as 2.7 kg/ha in Arunachal Pradesh and the region is default organic. Farming is predominantly rice-based with little exception in the state of Sikkim where maize is a dominating crop. Mixed farming system is the order as most of the farmers want to produce his household food and nutritional need without having to depend on outside sources. Agriculture and allied activities are the main source of livelihood for the people of this region and any attempt to reduce poverty as well as to place the region in developmental paradigm shall have to be based on system wise eco-regional planning of agriculture development.

SWOC analysis of the zone under ICAR-ATARI, Guwahati

This zone is characterized by diverse agroclimatic and diverse conditions. Temperature variation is between 25°C and 30°C in July and between 10°C and 20°C in January. The climate of the zone varies from tropical in the plains to Alpine in the high hills adjoining the Himalayas with altitude ranging between 97 m in the plains to 5000 m up in the hills. The annual average rainfall in the region is 2882 mm with range between 1341 mm and 3987 mm. This is a high rainfall area having large river basins. The forests occupy more land, followed by barren land leaving much smaller area for cultivation. Transport and communication system is very weak and a small proportion of sown area is irrigated. Shifting cultivation is noticed in about l/3rd of the cultivated area. Considering the adverse situation persisting in the zone, it become imperative for doing the SWOC analysis of the region to prepare the suitable futuristic plan of development.

Strength

- The institute is centrally placed in the center of North East i.e. at Guwahati which gives it the Strategic advantage.
- ICT enabled & trained staff with required technological backstopping.
- Presence of different ICAR institutes like ICAR - NRC PIG, ICAR-NRC Orchid, ICAR-NRC Yak and Regional center of different ICAR institutes like ICAR-CIFRI, ICAR-CPCRI, ICAR-NRRI, and ICAR-CRIJAF etc.
- The technology backstopping can be provided by the Assam Agricultural University, Jorhat through its colleges and dedicated agriculture and allied sector based Research Centre across the Assam.

Weakness

- Inadequate convergence amongst the stakeholders for service delivery.
- Inappropriate network amongst the KVKs and non-fulfillment of KVK ring.
- Time consuming reporting system and non-matching HRD needs of SMSs
- Weak transport and communication system across the region.
- Highly susceptible for natural calamity.

Opportunity

- Vast repository of untapped indigenous wisdom.
- Availability of large number of potential GI which can be branded and popularized
- Wider scope for Natural/organic farming and agro-eco tourism through KVKs.
- Act East policy of Govt. of India.

Challenge

- Attracting and retaining rural youth in agriculture vocation.
- Frequent occurrence of natural calamities and higher material cost.
- Shifting cultivation, soil acidity and climate change.
- Providing employment options through skill development.
- Ensuring technology access to marginal and small farmers.
- Doubling the farmers' income with the available resources.

Plan of work for realization of the vision

The plan is prepared in the following heads with the objective of producing skilled human resource for science and technology-led farmer centric growth leading to enhanced productivity, profitability and sustainability in agriculture.

A. Extension Research

- Improvement of shifting cultivation, conservation agriculture farming system and backyard farming system under changing climate scenario.
- Validation and refinement of ITKs and organic protocols following the principles of 'Farmer's FIRST' and their popularization.
- Development of innovative resilience model in consortium mode for nutritional and food security.

- Performance appraisal of different extension systems related to agriculture development in the region and its convergence.

B. Technology propagation & Developmental activities

1. *Creating a robust agricultural information network system*

- Development and use of dynamic online reporting portal for timely report submission by KVKs for easy monitoring and mid-term correction if any.
- Development of district wise digital agricultural databank in Northeast India.
- Preparation and publication of agro-climate zone specific technology inventory on varied subjects of interest to farmers in collaboration with AAU, CAU and ICAR Complex.

2. *Technology assessment, refinement and demonstration*

- Facilitating preparation of strategic plan for need based OFT and FLD in consultation with ATMA and other stakeholders for market-led extension.
- Formulating OFT to assess the demand driven and location specific technology under integrated farming systems and organic regime.
- Technology refinement in accordance with the existing soil, climate and available resources matching farmers' requirement.
- Conducting FLD on different tested and refined technologies for out scaling & up scaling of the same.

3. *Technology basket, capacity building and other developmental activities*

- Establishment of Technology Park for showcasing available technologies as well as agro-tourism development in selected KVKs.
- Enhancing availability of truthfully labelled seeds & planting materials through participatory seed programmes with appropriate buy back arrangement.
- Emphasis on income generating activities in each KVK through production of Bio-fertilizer, Bio-pesticides, carp/ poultry hatchery, value added products and tools & implements *etc*.
- Facilitating establishment of KVK in remaining districts of zone by 2020 and creation of infrastructural facilities in existing KVKs.

C. Positioning ICAR-ATARI Guwahati as a model R&D Institute

- Facilitating proper implementation of guidelines issued by the ministry for convergence between Agricultural research and extension.
- Regular publication of replicable success stories in Print and electronic media including Video film making and up grading of ATARI website.
- HRD for scientists/ technical/ administrative staff in reputed national and international organization.
- Publication of high quality research papers in peer reviewed journals including patenting shall be promoted.

D. Expected outcome

- Farmers and entrepreneurs with new knowledge and skills.
- Validated ITKs as a catalyst for promotion and expansion of organic agriculture in the region.
- Productivity and income enhancement for attaining self-sufficiency.
- Ready to use digital resource inventory for real time policy formulation for sustainable agricultural development.
- Agro-tourism spots for technology showcasing, income and employment generation.
- ICAR-ATARI Guwahati as Centre of Excellence in technology dissemination.

Conclusion

The ICAR-ATARI, Guwahati is in the nascent stage and it has to fulfill the expectations and responsibilities shouldered on it. There may be many hurdles will come in the way but they are the part & parcel of the journey and these should not hamper the goal set by the team ICAR-ATARI, Guwahati for the futuristic regional development. The states under its jurisdiction have the ample opportunities such as organic food production, spices, fruits, floriculture etc. which can be harnessed optimally for sustainable livelihood. It is not a distant dream which can't be achieved within the time frame but with proper action based plan, coordination among different stakeholders, efficient monitoring of the KVKs on execution of plan is sufficient to realize the dream.

Impacts of Climate Change on Pig Production: A Brief Review

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Introduction

Human population is expected to increase from 7.2 to 9.6 billion by 2050 (UN 2013). This represents a population increase of 33% and the global demand for livestock products including pork is expected to double by 2050, mainly due to improvement in the worldwide standard of living. Pigs are an important agricultural commodity for global food security because they provide livelihood and nutritional security to millions of people living in rural areas. The livestock sector contributes to the livelihoods of one billion of the poorest population in the world and employs close to 1.1 billion people (Hurst et al., 2005). Worldwide meat production will double from 258 to 455 million tonnes (Alexandratos and Bruisma,2012). Among the various livestock species, pig is the most potential source of meat as it is more efficient feed converters after the broiler. Apart from providing meat, it is also a source of bristles and manure. Pig farming also provides employment opportunities to seasonally employed rural farmers and supplementary income to improve their living standards. Meanwhile, climate change is a threat to pig and other livestock production because of the impact on production of quality feed crops and forage, water availability, reproduction due to heat stress, and increase diseases. Global climate change is primarily caused by greenhouse gas (GHG) emissions that result in warming of the atmosphere (IPCC, 2013). The livestock sector contributes 14.5% of global GHG emissions (Gerber et al., 2013) and thus may increase land degradation, air and water pollution. There is growing interest in understanding the interaction of climate change and agricultural production and it is motivating a significant amount of research. There is still limited research regarding the impacts of climate change on livestock production (IPCC , 2014).

Despite uncertainties in climate variability, the IPCC Fifth Assessment Report identified the “likely range” of increase in global average surface temperature by 2100, which is between 0.3 °C and 4.8 °C (IPCC,2013). The potential impacts on livestock include changes in production and quality of feed crop and forage (Thornton et al.,2009), water availability (Henry et al.,2012 Thornton et al.,2009), animal growth, diseases and reproduction (Nardone et al.,2010) etc. These impacts are primarily due to an increase in temperature and atmospheric carbon dioxide (CO2) concentration, precipitation variation, and a combination of these factors (Aydinalp and Cresser,2008; Henry et al.,2012, Thornton et al., 2009).

Impacts on feed crops production

Quantity and quality of feed will be affected mainly due to an increase in atmospheric CO2 levels and temperature (Chapman et al., 2012). However, the effects of climate change on quantity and quality of feeds are dependent on location and livestock system (IFAD, 2010). Increase of CO2 concentration will result in herbage growth changes, with greater effect on C3 species and less on grain yields (Chapman et al., 2012, Thornton et al., 2009 Thornton et al.,2015). Quality of feed crops and forage may be affected by increased temperatures and dry conditions due to variations in concentrations of water-soluble carbohydrates and nitrogen. Temperature rise may increase lignin and cell wall components in plants, which reduce digestibility and degradation rates (IFAD,2010), leading to a decrease in nutrient availability for livestock (Thornton et al., 2009). Extreme climate events such as flood, may affect form and structure of roots, change leaf growth rate, and decrease total yield (Baruch and Merida,1995).

Impacts on water

Global agriculture uses 70% of fresh water resources, making it the world's largest consumer (Thornton et al., 2009). However, global water demand is moving towards increased competition due to water scarcity and depletion, where 64% of the world's population may live under water-stressful conditions by 2025 (Rosegrant et al., 2002).Water availability issues will influence the livestock sector, which uses water for animal drinking, feed crops, and product processes (Thornton et al., 2009). The livestock sector accounts for about 8% of global human water use and an increase in temperature may increase animal water consumption by a factor of two to three (Nardone et al., 2010) As sea level rises, more saltwater will be introduced into coastal freshwater aquifers (Karl et al., 2009). Salination adds to chemical and biological contaminants and high concentrations of heavy metals already found in water bodies worldwide and may influence livestock production (Nardone et al., 2010).

Impacts on physiology and reproduction of pigs

All animals including pigs have a thermal comfort zone, which is a range of ambient environmental temperatures that are beneficial to physiological functions (FAO, 1986). During the day, animal keep a body temperature within a range of ±0.5°C (Henry et al., 2012). When temperature increases more than the upper critical temperature of the range (varies by species type), the animals begin to suffer heat stress (FAO, 1986). Animals have developed a phenotypic response to a single source of stress such as heat called acclimation (Fregley, 1996). Acclimation results in reduced feed intake, increased water intake, and altered physiological functions such as reproductive and productive efficiency and a change in respiration rate (Letera et al., 2003, Nardone et al., 2010). Global warming may reduce growth, carcass weight, and feed intake in pigs. Piglets' survival may be reduced because of a reduction of sows feed intake during suckling periods with temperatures greater than 25°C, which reduces the milk yield of the sow (Lucas et al., 2000). Reproduction efficiency of pigs may be affected by heat stress. Heat stress affects oocyte growth and quality (Barati et al., 2008, Ronchi et al., 2001) impairment of embryo development, and pregnancy rate (Hansen, 2007, Nardone et al., 2010, Wolfenson et al., 2000). Heat stress has also been associated with lower sperm concentration and quality in boars. Prolonged high temperature may affect metabolic rate (Webster, 1991), endocrine status (Johnson, 1980), oxidative status (Bernabucci et al., 2002), glucose, protein and lipid metabolism, liver functionality (reduced cholesterol and albumin) and non-esterified fatty acids of animals (Bernabucci et al., 2006, Ronchi et al., 1999). In addition to reproductive problems, heat stress also alters carcass composition (more fat and less lean). It is well known that pigs reared in heat-stress conditions have reduced muscle mass and increased adipose tissue (Collin et al., 2001).

Impacts on pig health and disease

Pig health can be affected directly or indirectly by climate change, especially due to increase in rising temperatures. The direct effects are related to the increase of temperature, which increases the potential for morbidity and death. The indirect effects are related to the impacts of climate change on microbial communities (pathogens or parasites), spreading of vector-borne diseases, food-borne diseases, host resistance, and feed and water scarcity (Nardone et al., 2010). Increase temperature could accelerate the growth of pathogens and/or parasites that live part of their life cycle outside of their host, which negatively affects animal. Climate change may induce shifts in disease spreading, outbreaks of severe disease, or even introduce new diseases, which may affect pigs that are not usually exposed to these type of diseases. Global warming and changes in precipitation affect the quantity and spread of vector-borne pests such as flies, ticks, and mosquitoes (Thornton et al., 2009).

Adaptation and mitigation strategies

There are several climate change adaptation and mitigation strategies that can be made for sustainable production. Adaptation strategies can improve the resilience of crop and pig productivity to climate change. Mitigation measures could significantly reduce the impact of climate change on pig production. Adaptation and mitigation can make significant impacts if they become part of national policies (FAO 2009). Adaptation measures involve production and management system modifications, breeding strategies, science and technology advances, and changing farmers' perception and adaptive capacity. Research is needed on assessments for implementing these adaptation measures and tailoring them based on location and production system. This could be accomplished with GIS and remote sensing technologies applicable at broad and local scales (Thornton et al., 2008). Changes in mixed crop-livestock systems are an important adaptation measure that could improve food security (Herrero et al., 2010, Wani et al., 2009). This type of agricultural system is already in practice in two-thirds of world, producing more than half of the milk, meat, and crops such as cereal, rice and sorghum (Herrero et al., 2012). Practicing mixed pig-fish-crop systems can improve efficiency by producing more food on less land using fewer resources, such as water. Improving feeding practices as an adaptation measure could indirectly improve the efficiency of pig production. Some of the suggested feeding practices include, modification of diets composition, changing feeding time and/or frequency (Renaudeau et al., 2012.) Changes in breeding strategies of pigs can help the animals for increase their tolerance to heat stress and diseases and improve their reproduction and growth development (Henry et al., 2012, Rowlinson, 2008). Modern pig farming is expected to produce more and more to satisfy the growing intake of animal protein whilst at the same time increasing animal health and welfare, reducing energy use and environ-mental footprint and coping with fewer and fewer suitable workers for the farms. Pig farmers need to focus on efficiency, large-scale production and maintain animal welfare.

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Animal Health Issues Pertaining to the North Eastern Region

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The north east comprises of seven states located with an extensive international boundary with China, Myanmar, Bangladesh and Bhutan. There is a constant threat of disease ingression into our country along this corridor. The extent of threat perceptions vis-à-vis the animal, human and environment continuum along with relevant technical aspects that are integral to the concept are described. According to the most recent FAO/OIE/WHO yearbook, the world animal population is estimated at 1.3 billion cattle (including 229 million dairy cows and 156 million buffaloes), 1.7 billion small ruminants, 900 million pigs, 58 million horses, 19 million camelidae and 12.2 billion poultry. The diseases that affect these animal populations vary depending on whether they have been extensively reared or intensively produced, especially in industrialised countries. Excluding diseases specifically related to intensive production systems, such as bovine spongiform encephalopathy or 'mad cow disease', (Kitching, 1997), as well as parasitic diseases, the major trends in contagious diseases (epizootics) can be identified. The most serious of these diseases, the so-called 'List A' diseases, which are the most damaging to the world economy and international trade, are all virus diseases. A few examples include Rinderpest (Crowther, 1997), which now only affects a few north-western areas of Sub-Saharan Africa, the Middle East and the Indian sub-continent and is controlled through a coordinated vaccination programme, the 'Global Rinderpest Eradication Programme' (GREP), aimed at eradicating the disease over the next ten years. Foot and mouth disease is either absent or under control in Oceania, Japan, the North American continent and the southern cone of Latin America, as well as in all western European countries. It is being closely monitored on the fringes of central Asia and there is a special disease control programme in south-east Asia. Contamination of a region by this disease can result in substantial financial losses because of the need to slaughter affected animals and impose an export ban. This was the case in Taipei, China, at the beginning of the year, when four million pigs were slaughtered over a period of a few weeks at a reported overall economic cost of 10 billion dollars (Donaldson, 1997)

Contagious bovine pleuropneumonia is still a major concern in Africa, with the exception of North Africa and Southern Africa. In east Africa it has developed rapidly, spreading to the south of the continent. This disease, which is a major obstacle to the development of cattle rearing, can be controlled by vaccination and/or slaughtering infected animals. Classical swine fever has recently made a spectacular comeback in Europe. The European Union's chosen strategy of slaughtering all diseased or infected animals has resulted in a very high number of animals having to be killed. The financial losses associated with this disease have topped 250 million US dollars in the Netherlands since the beginning of the year. African swine fever has been virtually eliminated from Europe. It persists in certain sub-Saharan African countries where it sometimes causes significant losses since no preventive vaccine is available. African horse sickness has been eradicated in Europe and North Africa and is no longer being reported in some African countries south of the Sahara. Newcastle disease can infect practically all birds in all countries of the world, including farmed poultry, pets and migratory wild birds and is controlled through vaccination. Other diseases (the so-called 'List B' diseases) are also a source of great concern in some regions and include rabies. Although rabies is coming under control in Western

Europe due to the oral vaccination of foxes, it is a growing threat in developing countries and more recently in eastern European countries. Each year, direct or indirect losses associated with the development or spread of all contagious animal diseases total billions of US dollars. A considerable effort is needed to control such diseases. Virus diseases are then predominantly trans-boundary in nature and affect both developed and developing countries. The importance of particular diseases and the control measures adopted often depends on the perceived economic importance even where resources are available. Diseases caused by viruses represent the largest general problem to human and animal populations, as well as to agricultural production in general, through damage to crops. Agriculture represents a large component in all economies and the results of virus diseases can be dramatically direct, through killing or severely disabling individuals; or insidiously chronic and be more difficult to recognize. Overall management of any disease requires that complex of methodologies is pursued within a relatively well developed infra-structure. Laboratory confirmation of diagnosis and the use of vaccines are two elements in control, but these can neither be disassociated from each other nor from other factors such as epidemiological surveillance, disease reporting, veterinary staff availability and mobilization, information exchange technologies and pure and applied scientific research.

Groups of animals affected should be considered since they focus on the problems associated with diagnosis and control. Diseases can be regarded according to incidence as endemic or exotic; and as to their infectivity and scale of effect. Endemic infections require eradication campaigns with the use of intervention measures e.g. vaccines and strict control measures, while exotic can be regarded as mainly animal control problems. The major livestock groups already mentioned, i.e. cows, sheep, goats, and pigs can be supplemented by wild animals; pets (dogs, cats, rabbits); zoo animals; laboratory animals- chimps, monkeys; guinea pigs, rabbits; mice; amphibians; fish, bees/insects and birds. Considerations of the interaction of species (including man) and disease agents also have to be made in control strategies. This is particularly evident in zoonotic diseases. Thus interventions also must include vector/pest control. Viruses are by their genetic nature obligate parasites. Consideration of developments in diagnostic methods and vaccines in general and animal viruses in particular, has to recognize the tremendous ability of viruses to rapidly produce mutations which, through selection, can exploit biological “niches”. Thus there is a constant evolution of potential “strains” which can exploit both there “normal” and also more “foreign” species. Indeed such exploitation can often result from direct intervention strategies, e.g. vaccination and from more indirect changes concerning human patterns of endeavor This contributes to the harmonization of methods of surveillance and control of important animal diseases and standard methods are described for laboratory diagnostic tests and the production and control of biological products (principally vaccines) for veterinary use in laboratories across the world. The availability of such standards should increase the effectiveness of measures undertaken to improve animal health worldwide. The OIE Manual has been written and revised by experts of established international standing and is unique in that each chapter has been approved by the Veterinary Services of all the OIE Member Countries.

The subject of “emerging diseases” caused by viruses has been developed for human diseases, (Morse and Schluederberg, 1990; Morse, 1993), but is no doubt also highly relevant in both the zoonotic diseases and those affecting only animals. Viruses are humanity’s only real competitors, acting as both parasites and genetic elements in their hosts. They show considerable genetic plasticity, enabling them not only to evolve in new directions, but also to produce genetic and metabolic relationships with cells, uniquely positioning them to mediate subtle, cumulative evolutionary changes in their host. This poses problems in vaccine design and strategies as well as to diagnostic methods. Virus diseases are also able to rapidly destroy large proportions of populations and the mere fact that long term natural selection favours mutualism offers only limited encouragement to our species, with millions of people and animals suffering before equilibrium can be reached. New patterns of human movement and practices, leading to new contacts across what had once been geographic boundaries, have been seen to give rise to a variety of emergent infections.

Most emergent viruses are zoonotic, with natural animal reservoirs a more frequent source of new viruses than from spontaneous evolution. Rodents and arthropods are most commonly involved in direct transfer, and changes in agricultural practices or urban conditions that promote rodent or vector multiplication favour increased incidence of disease. Other animals, especially primates, are important reservoirs for transfer by arthropods. Approximately 100 of the more than 520 known arthropod borne viruses (arboviruses) cause human disease. At least 20 of these might fulfill the criteria for emerging viruses, appearing in epidemic form at generally unpredictable intervals. These viruses are usually spread by the bites of arthropods, but some can also be transmitted by other means, for example through milk, excreta or aerosols. The arbovirus infections are maintained in nature principally, or to an important extent, through biological transmission between susceptible vertebrate hosts by blood-sucking insects; they multiply to produce viraemia in the vertebrates, multiply in the tissues of the insects and are passed on to new vertebrates by the bites of insects after a period of extrinsic incubation. The names by which these viruses are known are often place names such as West Nile or Rift Valley, or are based on clinical characteristics like yellow fever. Most arboviruses are spherical, measuring 17-150 nm or more, a few are rod-shaped, measuring 70 x 200 nm. All are RNA viruses. Many circulate in a natural environment and do not infect man. Some infect man only occasionally or cause only a mild illness; others are of great clinical importance causing large epidemics and many deaths. Specifically, these belong to the Togaviridae, the alphaviruses, flaviviruses, the Bunyaviridae, nairoviruses, phleboviruses and other subgroups. Vertebrate hosts can be defined according to their role in maintenance or amplification of virus. Maintenance hosts are essential for the continued existence of the virus and there is usually no actual disease, but the development of antibodies. These include migrating birds which travel over long distances carrying these and other similar viruses; rodents and insectivores such as rats, hedgehogs, lemmings and chipmunks are known to carry louping ill and Colorado tick fever; primates such as monkeys which carry Dengue fever; Leporidae (rabbits and hares) which carry Californian encephalitis; Ungulates (cattle and deer) which are implicated in the transmission of European tick-borne encephalitis; bats which carry Rio Brava virus; and marsupials, reptiles and amphibia such as kangaroos and snakes which also harbour encephalitis-causing viruses. Incidental hosts become infected, but transmission from them does not occur with sufficient regularity for stable maintenance. Man is usually an incidental host, often, but not always, being a dead end in the chain. These hosts may or may not show symptoms. Link hosts bridge a gap between maintenance hosts and man, for example, between small mammals and man by goats (via milk) in tick-borne encephalitis. Amplifier hosts increase the weight of infection, as is the case with pigs which act between wild birds and man in Japanese encephalitis.

Viruses are thus adapted to extremely diverse niches. Arthropod-borne viruses are spectacular examples of emergence and re-emergence resulting from innocent environmental manipulation or natural environmental change. Important aspects of ecological change and their relation to arbovirus life cycles are: 1) Population movements and the intrusion of humans and domestic animals into new arthropod habitats, particularly tropical forests; 2) Deforestation, with development of new forest-farmland margins and exposure of farmers and domestic animals to new arthropods; 3) Irrigation, especially primitive irrigation systems, which are oblivious to arthropod control; 4) Uncontrolled urbanization, with vector populations breeding in accumulations of water (tin cans, old tires etc.) and sewage; 5) Increased long distance air travel, with potential for transport of arthropod vectors; 6) Increased long-distance livestock transportations, with potential for carriage of viruses and arthropods (especially ticks); and 7) New routing of long-distance bird migration brought about by new man-made water resources.

Profile of Animal Health in the North east

Rapid globalization leading to increased trade and thus continuous movement of humans and animals, climate change, increased concentration of animals and humans pose an ever increasing threat of infectious diseases crossing the borders and leading to huge outbreaks. Outbreaks of exotic viral and bacterial diseases have become a real threat to animal populations worldwide in recent years. Outbreaks of FMD in UK in 2001 and 2007, Blue tongue in 2007, equine influenza in Australia in 2007 and India in 2008-09, highly pathogenic avian influenza (H5N1) are some of the glaring examples of the amount of devastation they can cause in terms of economic losses and damage to the industry. The scars from these outbreaks are stark reminders which make us sit and probe our capabilities to work towards creating technologies and garner our scientific knowledge in pursuit to overcome these infections. Theoretically, sealing our borders and stopping the movement of all human and animals can help us achieve the task but its sheer magnitude and enormity certainly make us ponder upon some better scientific means to find a sensible solution to this enigmatic problem of transboundary diseases. The sole mandate of this endeavor is to work on a roadmap to build our capabilities and strengths in the direction of developing latest diagnostics and organize rigorous surveillance for the highly contagious and ravaging (selected) diseases so as to have complete vigil on the disease situation of emerging and exotic infections and build a formidable defense to guard our territories, thus saving the livestock wealth and livelihood of millions of human beings involved with it.

The North Eastern Region of India has a diverse population of domestic livestock and wild fauna. This region is most favorable for livestock farming, as 60% grazing land is unfit for crop production and 40% people living below poverty line are dependent on micro and macro livestock farming for their economic support. The contribution of different livestock population to the total animal population of the nation (2007 livestock census) is – cattle-6.71%, buffaloe-0.61%, sheep-5.81%, goat-4.22%, pig-40.00%, yak-22.89%, mithun-11.00% and poultry 6.80%. Besides, there are sizable numbers of semi-domestic animals and large numbers of wild fauna. High rainfall and humid condition of this region probably favors rapid multiplication and maintenance of most of the infectious agents. In addition, there is close interaction between human, domestic and wild animals Moreover; the location of the eight northeastern Indian States itself is part of the reason why it has always been a hotbed of militancy with trans-border ramifications. This region of 263,000 square kilometers shares highly porous and sensitive frontiers with China in the North, Myanmar in the East, Bangladesh in the South West and Bhutan to the North West. The region's strategic location is underlined by the fact that it shares a 4,500 km-long international border with its four South Asian neighbours, but is connected to the Indian mainland by a tenuous 22 km-long land corridor passing through Siliguri in the eastern State of West Bengal, appropriately described as the 'Chicken's Neck. 'The North Eastern Region shares approximately 4500 km international boundaries with Myanmar, Bangladesh, Bhutan, Nepal and China. Uncontrolled migration of animals from neighboring countries, therefore, can be great threat for spreading of emerging and transboundary diseases to this region.

Current Scenario of Animal Health with regard to north east

The north eastern part of India has an extensive transboundary corridor (4500 kms) and has varied agro eco climatic zones. The topographical varieties of locations under the north east make this region a zone of biodiversity. Furthermore, considering the fact of proximity to other nations, there is a constant risk of disease incursion and emergence of novel disease phenomenon. This would be most evident considering the repeated outbreaks of avian influenza, sporadic outbreaks of Nipah, PRRS, West Nile and Swine flu in the region.

The main rationale from the NE perspective, are the ground realities in respect of the prevailing state of affairs in the region in the animal sector as mentioned below:

- Lack of a consortium approach among the contributing partners for rapid diagnosis and control of endemic, emerging and exotic diseases of livestock and poultry in the region
- Lack of an effective mechanism to train the field level workers to periodically update their knowledge and skill on sample collection methodology, modern diagnostic techniques so as to effectively deal particularly with emerging and exotic diseases.
- Lack of adequate infrastructure at the regional level in terms of state-of-the-art laboratories adequately equipped with sophisticated equipments necessary to rapidly diagnose

emerging and exotic diseases of livestock and poultry.

- Non-existence of a strong linkage between the state animal husbandry departments and research and diagnostic laboratories to make a concerted effort to deal with the situation arising out of an outbreak of emerging or TADs.

Profiles of various diseases in the NER and cross border transport

There is as yet no known assessment of the exact profiles of exotic diseases that are prevalent in the NER. Highly pathogenic avian influenza (HPAI) (Empres Document No 31, March, 2012) and Nipah (WHO fact sheet, No 262, Revised July 2009) are two of the most commonly encountered ones, apart from these cases of Dengue hemorrhagic fever of Cambodian origin (Ind J Med Res, 136, Oct 2012), West Nile virus (EID, Vol 17, May 2011), Scrub typhus (Ind J. Pediatrics, 78 (11), 2011), Japanese encephalitis (Southeast Asian J Trop Med Public Health. 2004 35(3)) has also been reported in the NER. Of particular concern is Nipah virus that has become endemic in Bangladesh. Nipah virus has emerged repeatedly into humans in Southeast Asia since 1997. The first cases were reported in Malaysia in 1998-1999, although retrospective diagnosis shows that human infections also occurred in 1997. Abattoir workers in Singapore who contacted imported pigs also became ill. During these outbreaks, most people were infected by contact with pigs, and human cases were not seen after seropositive animals had been culled. In contrast, some outbreaks in Bangladesh seem to be caused by direct or indirect transmission from fruit bats to humans, and may have been sustained by person-to-person transmission. These outbreaks have generally been seen from January to May, and usually occur in the same areas of the country. An outbreak in Siliguri, India in 2001 was linked to nosocomial transmission in hospitals, and ended after effective barrier nursing precautions were put in place. The area shares a huge transboundary corridor with Myanmar, China, Tibet, Bhutan and Bangladesh. Most of the borders are porous and there is a traffic or cross movement of livestock. Most of this movement is not recorded and is quite random in nature. It would also be worthwhile to mention that these movements are decidedly clandestine and have no official approval. The regular monitoring and surveillance of a group of selected diseases, under a structured programme, using “State–of-art diagnostics”, would prove worthwhile to develop effective preparedness and be informed beforehand of any emerging disease threat in this area.

Concept of Surveillance in North east

Surveillance is used to evaluate the effectiveness of control strategies, and to detect needs for mid-course adjustments in the programme. In the last stages of a disease eradication programme, surveillance becomes most important as a tool first for finding the last cases of the disease to be eradicated, and then for keeping a watchful eye for re-entry of the disease agent in the disease-free population. Regardless of the basic objective, the tools and components of a surveillance system are essentially the same, although there may be variations in the amount of emphasis put on the different components.

Performance indicators (PI’s) for effective surveillance

PIs are simply tools for evaluating the national surveillance, and assuring policy makers of the quality of the surveillance information they use to make decisions on disease prevention and control. They are useful in convincing national and international bodies (including neighboring countries, OIE, FAO, etc.) of the efficiency and efficacy of national surveillance. A high score on the PIs assures the CVO that a negative report can be interpreted as indication that there is no disease, and will provide essential support evidence for the freedom from disease and subsequent infection. Very often PIs are seen as static, statistical data calculated once a year by the government statistician, for purposes of determining poorly performing surveillance units. When properly set out, however, PIs should be dynamic and flexible, and targeted to specific, realistic and measurable goals, and will also indicate weak areas and how these could be corrected to improve the system. The CVO (or his schedule officer) should review the PIs on a regular (perhaps monthly) basis throughout out the year, so that corrective action can be applied when necessary. For instance, units that fail to report for two (or three) consecutive months should receive some input from headquarters — such as a letter requesting explanation, a telephone call, or preferably a visit from headquarters staff. Such dynamic response is preferable to a situation where PIs are calculated at the end of the year only to discover that some units have failed to report for five to six months. PIs should be seen as a dynamic tool for timely detection (and correction) of poor performance. PIs are applied to specific components of a surveillance system, and are designed to test those attributes that bestow high levels of efficiency on the system. Sensitivity, specificity, and timeliness are the main attributes of a good surveillance system, and these can be readily evaluated by PIs. High sensitivity is particularly important in the final stages of an eradication programme, when the ability to detect the last few occurrences of a disease becomes the determining factor in the success of the programme. Specificity measures the predictive value positive, the probability that a putative case actually has the disease (i.e. is not a false positive). Evaluation of sensitivity and specificity requires validation with laboratory diagnosis; consequently the proficiency of the national diagnostic laboratory is another measure of performance.

Timeliness is also just as important in the present situation with animal diseases of concern. Cessation of vaccination in several areas has resulted in the accumulation of a large pool of susceptible animals in many regional herds, with the potential for rapid spread of new infections. An outbreak report six months after it had occurred could be disastrous. Major epidemics can only be avoided through rapid identification and containment. There is also the added danger in the transhumant (nomadic) production systems as in most African countries, in that through unrestricted movement, the infected herd could spread the disease very rapidly. Other important attributes include simplicity, flexibility and acceptability. Simple and flexible systems that have direct flow of information are more responsive and more likely to generate timely reports than complicated systems, which are likely to be misunderstood and misapplied. Acceptability reflects the willingness of individuals in the system to participate in the surveillance activity. This attribute is particularly important in the developing countries where a great deal of the (passive) surveillance effort depends on the field worker, who is often poorly rewarded and poorly motivated. The design of the surveillance system ought to include some consideration and methods for motivating and rewarding the various participants in the system. The proportion of field workers who complete and submit the necessary reports on a regular and timely basis is one measure of the acceptability of the system.

Water Management for Sustaining Agriculture in Hill Ecosystems – Issues and Strategies

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Water is the key resource for sustaining all life on earth. It is a vital component of agricultural production and is essential to increase both quantity and quality of produce. Agriculture is the major user of water in most countries and currently this sector faces the enormous challenge of producing almost 50 % more food by 2030 and doubling almost 50 % more by 2050. This has to be achieved with less water resources, mainly because of increased competition arising out of growing population pressure, urbanization, industrialization and climate change. Over the past few decades, population growth and economic expansion has resulted in increased use and abuse of water leading to greater imbalance between water availability and demand. It is now well accepted that climate change may have large impact on water resources of a region mostly by affecting fundamental drivers of hydrological cycles. Increasing spatial and temporal variability and rainfall patterns (intensity, duration, frequency etc.) under the changing climate are also affecting the availability of utilizable water resources. Other processes like change in population size and location, economic development and land use, infrastructure, ground water development and changing social values etc. also have major influences on water resources and must be considered along with climate change in a holistic approach to water resource management (Brekke, 2009). India accounts for 4.0 % of global water resources and 2.45 % of land resources. The country also supports 16 % of global human and 15 % of global livestock resources. India receives about 400 million hectare metres of precipitation annually which is augmented by 20 m ha-m contributed by rivers flowing in from neighbouring countries. Net evapo-transpiration losses are nearly 200 m ha-m. About 135 m ha-m is available on the surface and the remaining recharges groundwater. With growing demand for water from the other sectors, availability of water for agriculture is likely to decline. As such, efficient utilization of water is of utmost importance. India has a highly seasonal pattern of rainfall, with 50 per cent of precipitation falling in just 15 days and over 90 percent of river flows in just 4 months (Sikka and Islam, 2015). India has already facing water stress condition with per capita availability of water declining sharply from 5177 m^3 in 1951 to 1544 m^3 in 2011 (CWC, 2013). It is projected to reduce further to 1465 m^3 and 1235 m^3 by the year 2025 and 2050, respectively, under high population growth scenarios (Kumar et al., 2005). The North Eastern Region accounts for 34% (653 BCM) of total water resources and 7.9 % of Indian land mass. The per capita availability and per hectare availability of water in this region is the highest in the country. However, less than 5% of the existing potential of the region is so far used for societal use. Against the ultimate irrigation potential of about 4.26 m ha, the area presently under irrigation is only 0.85 m ha. Although the availability of ground water at relatively shallow depth (within 20 m) is very high in this region, especially in the valley areas, only 4.3 % of the existing ground water potential has been developed so far. The region is endowed with average annual rainfall of 2500 mm with variability ranging from 1200 mm in some parts of Nagaland to 11,000 mm in Cherrapunji (Meghalaya). More than 70 % of the rainfall concentrates in four months (July - September) and unfortunately, the lion's share of the rainfall particularly in the hilly region is lost as runoff due to peculiar topography and absence of adequate storage device. Among the states, Arunachal Pradesh has the highest average runoff of 350 BCM (53.6 % of NER) followed by Assam 211 BCM

(32.3 % of NER) and Mizoram 31 BCM (4.7 % of NER). Total area covered by inland water in this region is 3,320 km^2. The rivers in the region have a combined stretch of 17,323 km and a total water area of 1817.5 km^2. Except for Tripura, ground water development is low in other states of North east. Assam has the highest ground water potential among the N.E. states, but presently 12.83 % of ground water is being utilized. The total replenish able ground water resource in Arunachal Pradesh is 1.44, Assam -24.89, Manipur-3.15, Meghalaya 0.54, Nagaland 0.72 and Tripura 0.66 BCM/year. The ground water will continue to play key role in meeting the water needs in spite of abundance rainfall and surface water availability. For augmenting ground water resources, exploration of prospects of development of springs, roof top rain water harvesting, construction of shallow tube wells are some of the welcome strategies. The climate change in north eastern region (NER) is also well perceived in the form of change in temperature, rainfall behavior over times. The annual maximum and minimum temperature from 1901 to 2003 has increased by 1.02^{o}C and 0.60^{o}C respectively. The temperature is projected to rise by another 3-5^{o}C during the latter third of this century (Cline, 2007). The changes in rainfall pattern in NER is well perceived in the form of change in total rainfall, frequent flood, drought etc. The frequent deficits in rainfall and the recurrent droughts in the region further substantiate the climate-induced alteration in the rainfall pattern (Manoj-Kumar, 2011). The change in climate may be due to various causes which may be summarized as due to Natural factors (volcanoes, ocean current, earth's tilt, variation in solar radiation received by earth, etc.) and anthropogenic factors like – burning of fossil fuel, change in land use pattern, industrialization, urbanization, deforestation, transportation etc. Expected consequences of climate change are warmer conditions, changes in growing period of crops, crop/plant migration, drought, extreme hot weather, storm and heavy rainfall/flood which are likely to bring both threats and opportunities. An average reduction in rainfall by 18 % and rainy days by 9 % in recent times compared to period 1951-1990 in the north eastern region has been reported by Saikia et al. 2012. Agriculture in the N.E.Region is mostly rainfed, subsistence type and suffers from a number of constraints. By and large, the region is characterized by fragility, inaccessibility and marginality. Floods, erosion, landslides etc. are common to the region due to its peculiar topography, geo-physical settings accentuated by faulty land use systems. The farmers of region are mostly small and marginal with small land holdings and low investment capacity.

An integrated and efficient management of water resources through proper planning is the need of the hour to enhance food, environmental and livelihood security of the fast growing population of the region. This implies management of water along with co-dependent natural resources viz., soil, vegetation, forest, air and other soil biota. A key challenge for decision makers, policy makers and departments is to understand the strategies adopted by the farmers and other stakeholders in their efforts to address climate change induced water stress. Small holder farmers are most vulnerable to climate change and then have no alternative but to adopt their livelihood system to changing climatic conditions. Water resource management strategy is thus key to ensuring that agricultural production withstand the stresses caused by climate change. The present poor performances in terms of water use efficiency plus competition over diminishing water resources warrant the need for investment in better water management systems. In view of limited access to irrigation, small farmers need to develop water conservation in-situ or ex-situ, rain water harvesting systems to maximize on-farm water management. Water management is also improved by having a greater diversification options for water sources, such as small streams, shallow well, bore well and rain water storage. Other options such as micro- irrigation (drip, sprinkler), water lifting devices (gravity, manual and pumps – motorized, solar etc). Crop diversification and insurance, information management and capacity building among farmers and other stakeholders is also important in the overall strategies of water resource management. Rain water harvesting, proper management of existing water resources, watershed development and community participation will help to attain sustainable utilization of water for agriculture and uplift socio-economic conditions of the people. The stored water in "Jalkund could partly be used for crop production and partly for livestock/fish production. Creating awareness among the people about environmental and anthropogenic facts behind floods, droughts, scarcity of water and sustainable development of water resources of the region by involving the people and utilizing indigenous knowledge and technology at the same time seems to be urgent need. Upgrading the rainfed agriculture through integrated rainwater harvesting systems and complementary technologies such as low cost pumps and water application methods, such as low head drip irrigation, runoff storage through farm ponds, micro rain water harvesting structures, earth dams etc. are some of the desired interventions. The sustainable livelihood in hills could be achieved by focusing on the improvement of quality of household livelihood by harnessing local resources, which are compatible with the mountainous agro climatic situation. In general, adaptation in rainfed agriculture may be brought about by introduction of improved climate resilient crop cultivars, by modifying existing cropping pattern, diversifying the crops, introducing suitable water supply, irrigation, drainage systems and resource conservation technologies. raised and sunken bed systems helps in crop diversification and better water use efficiency. Concerted efforts are required from water harvesting to distribution and application so as to maintain a proper water balance. Efforts are also needed to develop water resources in an integrated manner at basin level to not only sustain agricultural production but also protect the environment and meet the increasing water requirements in other sectors. Watershed as a tool for soil and water conservation (SWC) measures as well as for socio-economic development of community is already a widely accepted fact. The component of the watershed includes socio-economic survey for analysis of resource status, water harvesting structures, construction of bench and half moon terraces along with other agronomic measures for SWC, introduction of HYV crops, fruits and vegetables etc. Increasing scientific and social awareness among the farmers to educate and prepare them to face the consequences of climate change is an integral part of overall adaptation strategy. This may be achieved through effective short/medium term climate predictions and dissemination and introducing suitable and easily accessible microfinance and insurance facilities. Crop diversification, resource conservation practices, adoption of location specific integrated farming system modules, promotion of production and use of organic manures, appropriate low water demanding crop rotation, crop varieties, agro-techniques such as direct seeding, zero tillage, system of rice intensification, low water demanding crops like pulses and oilseeds, adoption and improvements of traditional water management practices etc. are some of the options for consideration in the overall strategy of efficient water management in the region.

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Genetic Improvement of Harar (*Terminalia chebula* Retz.)

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Introduction

Terminalia chebula is one of the very important indigenous multi-purpose tree species belongs to Family Combretaceae and popularly known as “Myrobalan” and it is commonly known as Harrar, Harra, Hirda and Haritaki. In India it is distributed throughout the greater part except arid zone (Troup, 1921). It is found in sub Himalayan tract from the Ravi eastward to West Bengal and Assam, ascending upto an altitude of 1,500 m in the Himalayas, whereas in Himachal Pradesh it is confined to sub-tropical zone (400-900 m elevation) in pockets. In peninsular India, it is found in mixed deciduous forests to dry deciduous forests and extend upto elevation of 900 m. It can grow in different environmental conditions. Soil supporting Harar vary widely in depth and composition. It also withstands fire and exhibits a remarkable recovery from scars and burns after fire. It coppices very well,the coppice-shoots being often very vigorous. It is a moderate-sized to large deciduous tree of the sub-tropical climate with a rounded crown, spreading branches and usually a short trunk. Bark is dark brown, often longitudinally

The species is prized for its fruit which has medicinal value. The fruit is extensively used for the treatment of diarrhoea, dysentery, heartburn, flatulence, dyspepsia and liver as well as spleen disorders. It is one of the main constituents of trifla which is a known panacea for stomach disorders. In addition to medicinal properties, Harar fruit is used in tanning and dyeing industries. The tree is lopped for fodder in some areas during lean period and also provides good quality durable timber.

The annual demand for the Harar fruit in India is 6778.4 tonnes which is growing @ 4.6 per cent annually.The fruit both fresh and dried has a ready market at Amritsar, Hoshiarpur and Delhi. The fruit is also exported to Pakistan and Gulf countries. The harvesting of fruits starts from Aug- Sept and continues till January. Majority (90%) of the trees bear small sized fruits of inferior quality locally known as kachra. Large sized fruits fetch a premium price, minimum three times higher to that of kachra type. Varieties with large fruits are used for making ‘Murabba’ and are, therefore, called as ‘Murrabi’ variety. The fruits of murabbi varieties are three to five times larger as compared to that of kachra type. The cost of picking, grading and transportation being the same for low as well as high quality fruits, profit margins are far less for low quality fruits. Artificial reproduction of harar is through seedling plants which show wide variation in growth, size and quality of fruits. However, the farmers are interested in true to type plants with early bearing quality fruit. This paper describes the work done in this species in order to develop suitable varieties and propagation techniques. As Harar is well distributed in the North East region, suitable strains and propagation techniques already standardized can be planted in this region for the benefit of farming community

Reproductive Biology

The reproductive biology studies have suggested that leaf fall and flushing events occur during pre-monsoon season; leaf flushing extends into the monsoon season. Flowering occurs during late dry season and early monsoon season. The flowers are bisexual and obligately outcrossed and this is enforced by self-incompatibility. Protogyny is a device to promote outcrossing, but it is weak. However, it is partly substantiated by gradual anther dehiscence over a period of six hours. The plant is entomophilous and cross-pollination is effected mainly by 42 species of insects including large bees, wasps and butterflies. The natural fruit set is around 7.83% as against the 65.67% realized in manual xenogamous pollinations. The study suggests that T. chebula does not suffer from pollinator limitation to maximize fruit set but from the limitation of compatible pollen and flower. Fruits fall to the ground when mature and dry, but wind is also instrumental in shedding fruits. The fallen fruits are dispersed by mainly animals and then to some extent by rain water and finally the seeds germinate and establish seedlings depending on the soil status.

Regeneration status of Harar:

The study was confined to five natural populations of Harar (*Terminalia chebula* Retz) distributed in three districts of Himachal Pradesh. In every natural population quadrats were laid down randomly to study the regeneration status along with percentage size class (girth class) occurrence of Harar trees. Most of the individuals in these populations were found to be almost of the same size producing flowers and fruits but no seedlings had been successfully established showing complete absence of natural regeneration of Harar (recruits, un-established or established) within its natural populations. However recruits of Harar were found in some agricultural fields of Jamun Ki Sair and recruits, un-established and established regeneration was found in grassland in the buffer zone of natural population in Rakkar. Complete absence of natural regeneration of Harar in its natural population confirms the urgency of propagation of the species with the help of artificial techniques, reduction of destructive harvesting methods such as hacking tree branches and lopping pressure, establishment of community-based pulp extraction enterprises near the forest ecosystem to help in returning back the seeds to the ecosystem enabling greater chances of regeneration by extracting the pulp and reusing the seeds for regeneration.

Variation studies

Wide range of variation was found in different fruit and seed characteristics (Table 1). Fruit length varied from 3.17 cm to 7.80 cm whereas fruit diameter ranged from 1.98 cm to 3.57 cm. Large variation was also found in fresh fruit wteight (11.5–38.45 g) and dry fruit weight. (3.99- 15.45 g). Variation in fruit size and weight indicate that selection could be effective for large sized fruits.

Table 1: Variation for fruit and seed characteristics in *Terminalia chebula* accessions

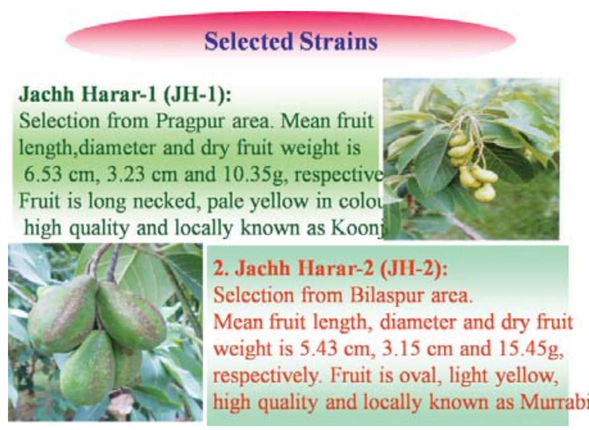
Character	Minimum	Maximum
Fruit length (cm)	3.17	7.80
Fruit diameter (cm)	1.98	3.57
Seed length (cm)	1.43	3.36
Seed diameter (cm)	0.64	1.71
Fresh fruit wt. (g)	11.5	38.45
Dry fruit wt. (g)	3.99	15.45

Selection of Superior strains

Four promising strains as per evaluation of the scientists associated with the work and substantiated by the farmers and traders have been identified.

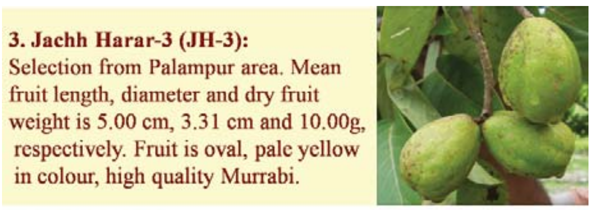
i) Jachh Harar -1 (JH-1): Selection from village Pragpur, Tehsil Dehra, District Kangra. Mother tree age, height, girth, spread were 90 years, 18.0 m, 1.60 m and 16.40 x 12.30 m, respectively. Mean fruit length, diameter and dry weight is 6.53 cm, 3.23 cm and 10.35 gm, respectively. Fruit is long necked, pale yellow in colour, high quality and locally known as koonj.

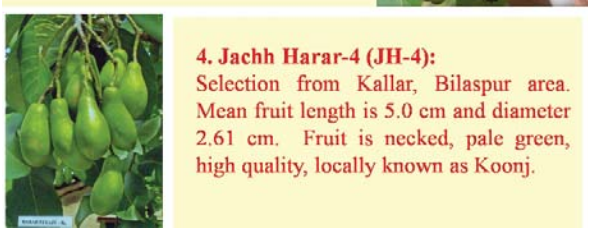
ii) Jachh Harar -2 (JH-2): Selection from village Kothi Harar, District Bilaspur. Mother tree age, height, girth, spread were 250 years, 12.5 m, 2.20 m and 24.0 x 22.0 m, respectively. Mean fruit length, diameter and dry weight is 5.43 cm, 3.15 cm and 15.45 gm, respectively. Fruit is oval, light yellow with reddish tinge, high quality Murabbi type.



iii) Jachh Harar-3 (JH-3): Selection from village Tamber, Tehsil Palampur, District Kangra. Mother tree age, height, girth, spread were 70 years, 22.0 m, 1.65 m and 15.0 x 13.5 m, respectively. Mean fruit length , diameter and dry weight is 5.00 cm, 3.31 cm and 10.00 gm, respectively. Fruit is oval, pale yellow, high quality Murabbi.

iv) Jachh Harar-4 (JH-4): Selection from village Kaller, District Bilaspur.. Mean fruit length , diameter and dry weight is 5.00 cm, 2.61 cm and 12.00 gm, respectively. Fruit is necked, pale green, high quality Koonj.





Biochemical Analysis of fruit

For biochemical analysis, fruit from different seed sources from of Himachal Pradesh was analysed for macro and micro minerals, tannins, Vitamin C and other biochemical traits. As evident from the Table 2 & 3, significant variation was found for these traits in different seed sources. Overall, profile of various macro & micro minerals as well as other chemical nutrients showed that fruits of *T. chebula* are highly nutritious

Table2: Macro and micro mineral contents(mg/ 100 g) in *Terminalia chebula* fruits of different accessions.

Macro & Micro Minerals	Range	Mean
Phosphorus	47.65- 92.21	65.14
Sulphur	51.14- 65.20	59.57
Zinc	0.348- 1.013	0.574
Copper	0.167- 0.332	0.177
Magnesium	30.60- 59.88	45.96
Calcium	40.96- 103.00	73.25
Mangenese	0.049- 0.232	0.117
Potassium	341.2- 502.6	382.2
Iron	1.141- 1.606	1.446

Table 3: pH, titrable acidity, ascorbic acid, total carbohydrates, tannins, ash, nitrogen and proteins of *Termialia chebula* fruits of different accessions.

Biochemicalconstituents	Range	Mean
PH	3.482- 3.915	3.841
Titrable Acidity	545.80- 900.80	718.8
Ascorbic Acid (mg/100 g)	5.765- 11.920	7.763
Total carbohydrates (%)	3.708- 6.514	5.097
Tannins (%)	27.27- 40.01	33.25
Ash (%)	3.410- 3.602	3.510
Nitrogen (%)	0.152- 0.315	0.219
Protein (%)	0.953- 1.968	1.384

Propagation studies

Seed germination studies

Harar seed is obstinate to germinate. Our studies indicated that dormancy is mechanical due to hard endocarp which allows water and air to pass inside freely but caused obstruction to embryo growth. Different pre-treatments given to soften the hard endocarp had resulted in variable response. Maximum germination (45 %) was observed when kernel was extracted from hard seed coat.

Grafting studies:

Maximum grafting success (88-89 %) was observed in the month of May and June followed by July and August (85 & 84 %) under poly cap technique.

Molecular characterization

Unweighted Pair Group Method with Arithmetic Mean (UPGMA) dendrogram based on ISSR markers resolved into four major clusters (Fig.). The similarity coefficient among 8 genoytpes ranged from 0.22 to 0.67. A critical perusal of dendrogram revealed that the distribution of various genotypes into clusters and within cluster was somewhat random. Cluster one comprised of only one genotype viz. P-7, showing 22 per cent similarity with rest of the genotypes under study. Cluster II comprised of two genotypes viz. P-1 and P-6 showing 30 per cent similarity with cluster III and *67* per cent similarity between the two. Thus, these genotypes showed maximum degree of similarity in their genetic makeup. Whereas, genotypes P-6 and P-5 showed least similarity index (0.10) amongst the genotypes studied. On the basis of banding pattern ISSR's were effectively used for molecular characterization of Harar genotypes used in this study.

Cluster III comprised of two genotypes *viz.*, P-3 and P-8 showing 54 per cent similarity in their genetic makeup. Cluster IV a major cluster having three genotypes were grouped in to two sub clusters. Sub cluster one having genotype P-4 showed 38 per cent similarity with sub cluster II. Second sub cluster comprised of two genotypes *viz.*, P-2 and P-5 which showed 44 per cent similarity between themselves. Cluster I, the most diverse cluster was having one genotype P-7. It showed clear-cut distinction from rest of the genotypes of the cluster and had different genetic makeup.

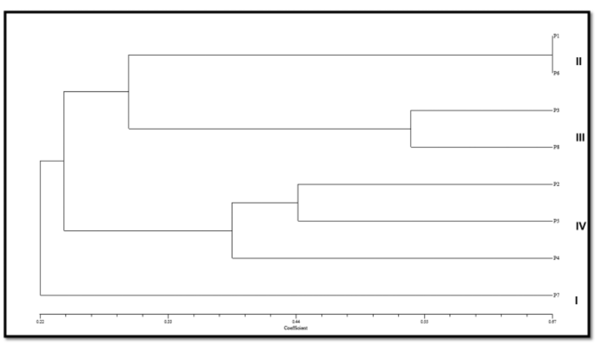


Figure: Dendrogram based on UPGMA analysis of 8 genotypes of Harar using ISSR Markers

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Role of Information and Communication Technology in Smart Farming

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The information and communication technology (ICT) play an important role in daily life of an individual. It becomes a vital communication tool cutting across gender, place and also the different classes of society. The agriculture is the mainstay of Indian economy and the major challenge in the present era is improving the production scenario in a situation of waning natural resources required for production. Information unlike other factors of production should be well thought-out as an input factor for sustainable agricultural production. Decade ago there was plenty of literature available on "Digital Divide" that differentiated the countries with IT infrastructure from the countries that were lacking the same. Now that huge investment on IT infrastructure development in rural India by renowned NGOs and funding organizations have neutralized the effect of digital divide and India is in a state to access information virtually. Present hitch is of "Knowledge Divide" or "Information divide" that is getting hold of the pulse. Inadequate and inefficient dissemination of relevant information to the farming sector is the bane to Indian agricultural system and not lack of R&D efforts. The people need agricultural information to be passed and received quickly. This paper objective is to highlight the role of ICT in research and extension activities with the special emphasis on Indian experiences.

Information and Communications Technology (ICT)

It is defined by Michiels and Van Crowder (2001) 'is a range of electronic technologies which when converged in new configurations are flexible, adaptable, enabling and capable of transforming organisations and redefining social relations'. They are technologies that can be used to interweave information technology devices such as personal computers with communication technologies such as telephones and their telecommunication networks. ICT is often used as an extended synonym or as an umbrella term for information technology (IT), but is a more specific term (i.e. more broad in scope) that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information (Wikipedia, 2015).

ICT in research

This concept has been widely in use and incorporates the theme of participatory methodology. As a case, ICT may be used in farming system research. In this approach, the participation of client i.e., farm men, farm women, youth farmer, other stakeholders and location specific development of technology and dissemination is central to the theme of farming system research and extension. It takes into account the holistic and interdisciplinary nature and targets the multiple goals of the farm family as well as the economic and resource situation in which the farm family operates. The client participatory nature of FSR/E enhances the capability of research and extension organizations to incorporate farmers' goals, resources, concerns with their own future, and their experience into the technology generation and diffusion process and farmers with similar conditions and the specific recommendations are grouped into identifiable recommendation domain (Francis, C.A and Hildebrand, P.E, 1989). A wide information gap exists between research and realism and the farmers need timely expert advice to become more productive and competitive. The current state of extension agent to farmer ratio as reported by the Working Group Report of the Planning Commission XII five year plan is 1:1500 which makes transfer to technology by traditional approach next to impossible. Though India ranks second highest in number of extension agents (1,10,000) in the world it is still not enough to meet the needs of efficient and effective ToT (Meera *et.al.,* 2010). Traditional Agriculture Extension System is characterised by linearity that includes only the researchers and the farmers excluding all the other stakeholders such as universities, agribusiness traders, non-governmental and civil society organizations that also constitute the networking system of the farming sector through whom the actual agricultural innovations occur. Indian Agriculture extension system is traditionally funded, managed and delivered by the public sector that played a major role in ushering green revolution in Indian agriculture (KM Singh *et.al.,* 2013). As today's farming is becoming highly knowledge intensive, commercialized, competitive and globalised against traditional approach, the call for the precise approach to draw together collaboration between the researchers, farmers, extension workers, agri-business traders and civil societies will lead to what we aim at "development".

ICT engage stakeholders in formulating the ambitious research program:

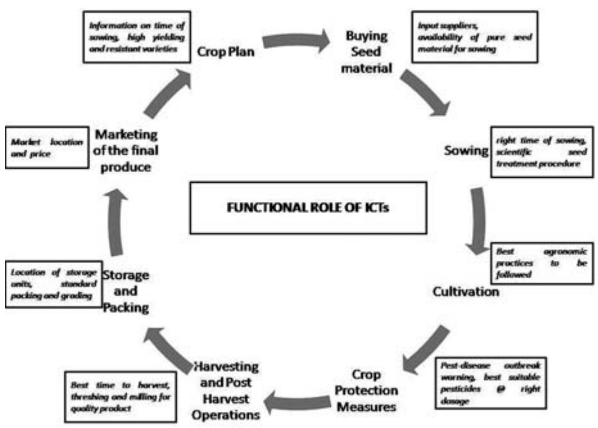
ICT plays an important role of enhanced interaction and communication by integrating various stakeholders into research. This results in enhanced communication, wider knowledge and in depth understanding and clarity of the project. The below is the case study which narrates the importance of ICT in research project formulation.

In summer of 2010 four international agricultural research centers of Consultative Group of International Agricultural Research (CGIAR) came together to develop an ambitious research project by consulting various stakeholders on innovative, inclusive research program on livestock and fish. In this program, the various stakeholders were consulted personally as well as online supported by wiki (to enable documents for sharing with all), blog

Box : Need for ICTs

1. ***To hasten agricultural growth*** - *need of energetic, vibrant and novel approach to be adopted in order to achieve targeted growth rate and provide the farmers better livelihood by integrating ICT applications in agricultural extension.*
2. ***To increase knowledge reserve*** - *Food security greatly depends on ¯Knowledge Resource. ICT can complement the traditional extension system for ¯Knowledge Resource delivery to the millions of the farmers.*
3. ***To aid in better information access*** - *Convergence of ICT with traditional extension system will develop the farmers'information access.*
4. ***To add-on inadequate technical manpower*** - *Inadequate technical manpower to some extent can be compensated by the extensive use of ICTs.*
5. ***For stronger research-extension client system linkage*** - *Feedback received through ICTs can facilitate stronger linkages with research-extension-client system to be more accurate and quicker.*
6. ***For cost-effective agro-advisory*** - *The ICT tools like Internet and mobile networks provide agro-information services that are relevant, affordable, dynamic, and highly accessible and farmer friendly.*
7. ***To develop knowledge managers*** - *Emergence of knowledge workers result in the realization of bottom-up, demand driven paradigm for technology invention, evaluation, improvement and adoption.*
8. ***To ensure gender equity in technology transfer process*** - *ICT enabled extension system overrides the gender bias and provides equal opportunity to the farm women.*
9. ***To empower small and marginal farmers*** - *Empowering small and marginal farmers with the right information at the right time and at right place is vital for improving effectiveness and liveliness of small and marginal holding.*
10. ***To serve the farm stakeholders beyond technology transfer role –*** *The expanded role of extension systems should be equipped with ICTs should go beyond transforming from new food crop technology to access to export markets.*

(assumptions and questions were posed and comments were received through this) and survey monkey tools (for several online surveys). For this program the e- consultation began on July 2010 and ended in March 2011. It consists of eight rounds of questions and after five rounds of discussion, initial proposal was formulated. During this period the various e-consultation tools and resources were viewed more than 25000 times and organizers received more than 465 comments and other feedback for the project (Rudgard et al.,2015)



Functional role of ICTs in addressing the information needs of the farmers through the agricultural cycle

The information need of the farmers is a cyclic process and keeps changing along with the cropping period and therefore the information provided should also correspond to the changing information needs accordingly. Of the array of information required, studies has revealed that small farmers rated weather, plant protection (disease/ pest control), seed information and market prices as the most important (Mittal et al., 2010.). Almost 46.9% of the farmers said that the biggest constraint they face to improve their productivity is lack of access to any extension service or credible information source (Surabhi Mittal and Mamta Mehar, 2012). At each crop growing stage, the application of ICTs range from that of information providers to diagnostic measures, aid in better decision-making abilities and high price realization of the final produce. When the above cycle is categorized into different sectors of ICT roles we can see that crop plan, seed material procurement, sowing and cultivation come under information providing category, crop protection measures come under diagnostic and advisory category, harvest and post harvest operations and storage and packing can be categorized into decision-making category and marketing of the final produce to the consumers is influenced by the market intelligence. The ICT tools that are used to provide information at the above stages of crop growth are kiosks, CSCs, web portals and mobiles. Using these tools specific need-based information can be provided to the farmers and help them better access to information and enhance their production. Not just advisory information, but a complete resource package across the agricultural value chain needs to be provided (Raj Saravanan *et.al.,* 2015).

ICT initiatives in Agriculture Extension: National Experiences

Many initiatives have been taken up by the Ministry of Agriculture and Farmers Welfare and the private sector to harness the potential of ICTs in agriculture and provide better cost effective and timely information services to the farmers. Even though public investments in agriculture sector-based ICT initiatives are low, but with immense attention from the private sector, a number of such initiatives are being developed and implemented in India. The initiatives taken are in the form of information centres, web-based portals and mobile based agro-advisory services both in PPP mode and individual approach. ICTs being employed in extension could be broadly classified (Table 1& 2).

The exhaustive catalogue of ICT mediated projects in India in the field of Agriculture and Rural Development by public, private and civil societies gives us a depiction of the extent to which ICTs are deployed in rural India. In spite of having such a gigantic database of ICT projects still there exists a technological gap between the farmers and other stakeholders leading to distress production and forced sales. The reasons for the failure in use of the available tools and technologies accounts to multiple factors covering from the policy makers to the ultimate users.

Table 1: Agriculture Information dissemination using Internet (Public, Private and NGO)

S. No.	Initiative Name	Year of Initiation	Initiator	Region of Country	Organization
1.	National Agriculture Portal	2016	Ministry of Agriculture and Farmers Welfare	India	Govt.
2	KIRAN (Knowledge Information Repository of Agriculture in the North East)	2012	ICAR Research Complex, Barapani	North East	Govt. (ICAR)
3	Rice Knowledge Management Portal (RKMP)	2009	DRR, ICAR	India	Govt.(ICAR)
4	e-gram Vishwa Gram Project	2009	Govt. of Gujarat	West	Govt.
5	Integrated Citizen Facilitation Centres (SETU)	2009	Setu Society (an NGO), Maharashtra	West	NGO
6	AGROPEDIA Beta	2009	NAIP	North, West	Govt.
7	TNAU Agri Tech Portal & Dynamic Market Information	2009	TNAU, Coimbatore	South	Govt.
8	e-gram	2009	Govt. of Rajasthan	North	Govt.
9	APOnLine	2008	Govt. of Andhra Pradesh	South	Govt.
10	DSC (Development Support System)	2008	IBM Worldwide Telecom Web Group	West	Private
11	Entegramam	2008	Govt. of Kerala	South	Govt.
12	SEEDNET	2008	Ministry of Agriculture	East	Govt.
13	Sahaj Tathya Mitra: Common Service Centres	2007	SREI infrastructure finance ltd.	East	Govt.
14	Agro Sense	2007	Media lab Asia and IIM Kolkata	India	Govt.
15	V-Aqua	2007	Byrajju foundation	South	NGO
16	ICT intervention for Farmers through Query Redress Services	2006	Indian Agribusiness Systems Private limited	West	Govt.
17	Sustainable Livelihood Improvement	2006	JIBAN BIKASH (NGO)	East	NGO
18	n-Logue Telecentres	2006	n-logue Communications Private	South	Private
19	Bhu-Rekha/Land Records Information System	2006	Govt. of Kerala	South	Govt.
20	Village Information Centre	2006	DHAN Foundation (TATA)	South	NGO
21	Gramin Gyan Kendra	2006	Media Lab Asia and BHU Varanasi	North	Govt.
22	Agri planning in Khasi Hills (VRC)	2006	North east space application centre, Meghalaya	North East	Govt.
23.	AGRISNET	2005	Dept. of Agriculture and Cooperation (DAC), Ministry of Agriculture, GOI	East, South	Govt.
24	Coil-net:A cultural Heritage Digital Library	2005	Dept. of IT, Ministry of Communications and Information Technology (MoCIT), GOI	East North	Govt.
25	Creating Rural Entrepreneurs through ICT enabled Enterprise Development Services	2005	Development Alternatives (TARAHAAT informational & marketing services ltd.)	West North	NGO
26	e-Krishi/Agri-Buisness centres	2005	Akshaya e-kendra entrepreneurs	South	NGO
27	Kisan Soochna Kendra (KSK)	2005	IIT-Roorkee	North	Govt.
28.	Bhu-bharati/The Integrated Land Information System (ILIS)	2005	Govt. of Andhra Pradesh	South	Govt.
29	e-Sagu	2004	Media lab Asia and IIIT Hyderabad	India	Govt.
30	Gender Resource Centre (GRC)	2004	Ministry of Agriculture GOI	India	Govt.
31	Rural Knowledge Centre (RKC)	2004	Microsoft corporation India Pvt Ltd. NASSCOM Foundation and ICRISAT	East, South, West	NGO

32	i-Shakti	2004	Unilever	South	Private
33	OSCAR (Open Source Simple Computer for Agriculture in Rural areas)	2004	IFP (French institute of Pondicherry)	India	Private
34	Samanya Mahiti	2004	A public sector initiative of rural Dev and Panchayati raj Deptt	South	Govt.
35	BHOOMI	2004	Govt. of Karrnataka	South	Govt.
36	Tamil-Nilam	2004	Govt. of Tamilnadu	South	Govt.
37	Rajiv Internet Village Programme	2004	Govt. of Andhra Pradesh	South	Govt.
38	i-Kisan	2004	Nagarjuna Fertilizer & Chemical Limited Group Hyderabad	North, South West	Govt.
39.	Pulse Pest Control	2004	IIPR, Kanpur	North	Govt.
40.	aAqua	2003	Media Lab Asia and IIT Bombay	India	Govt.
41.	AGMARKNET	2003	Deptt. of Marketing & Inspection (DMI), Ministry of Agriculture, GOI	India	Govt.
42.	ASHWINI	2003	Media lab Asia and Byyraju Foundation	South	PPP
43.	Computer on Wheels	2003	Global Catalyst Foundation	South	Govt.
44.	DACNET (Department of Agriculture and Cooperation Network)	2003	National Information Centre (NIC), Ministry of Agriculture, Govt. of India	North, West	Govt.
45.	Digital Mandi	2003	Media lab Asia and IIT Kanpur	India	Govt.
46.	E-krishi Viapnan	2003	Madhya Pradesh Govt.	West	Govt
47	Information and Communication Technologies for Development (ICTD): Making ICT Work for People	2003 .	Deptt. of IT GOI (Gachi bowli)	India	Govt
48	Interlingua Web	2003	Media lab Asia and IIT Bombay	India	Govt.
49	Jagriti e-Seva	2003	Jagriti (NGO)	North	NGO
50	Jamset Ji Tata National Academy for Rural Prosperity	2003	MSSRF (MS Swaminathan Research Foundation)	South	NGO
51	KISSAN Kerala	2003	Indian Institute of IT and Management –Kerala (IITM-K)	South	Govt.
52	Murugappa Group EID Parry	2003	EID parry	South	Private
53	Tata Kisan Kendra	2003	Tata chemical	North	Private
54	RASI (Rural Access to Services through Internet) MAIYAMS	2003	FOOD (Foundation of Occupational Development)	South	Govt.
55	VASAT Project	2003	ICRISAT	South	Govt.
56	DHARITREE	2003	NIC	North East	Govt.
57	Online Market Information System	2003	Govt. of Meghalaya	North East	Govt.
58	e-Arik	2002	Central Agricultural University, Arunachal Pradesh	India	Govt.
59	Gyansanchar	2002	CIDA, BSNL, Govt. of MP	West	Govt.
60	Digital Payment System	2002	Vidya Pratishthan's Institute of Information Technology Baramati-India (Public sector)	West	Govt.
61	Community Information Centres (CICs)	2002	Deptt. of Information Technology, Ministry of Communications & Information Technology, GOI	North East	Govt.
62	HP iCommunity	2002	HP, Govt. of AP	South	Govt.
63	Swajaldhara	2002	Ministry of Rural Dev	North	Govt.
64	Agriwatch Portal	2001	Indian Agribusiness systems Pvt. Ltd. (IASL)	India	Private
65	ASHA	2001	National Information Centre (Public Sector)	North East	Govt.
66	Graphical Mode of Navigation for IFFCO Kiosks	2001	IFFCO	North, East, South, West	Govt.
67	ISAP India	2001	Deptt. of Science and Technology	West	Govt.

68	Maha-Agrinet	2001	Govt. of Maharashtra	West	Govt
69	Krishi Marata Vahini	2001	Govt. of Karnataka	South	Govt.
70	ATICS	2001	ICAR	India	Govt.
71	Gyandoot	2000	Govt. of Madhya Pradesh	West	Govt.
72	ITC e Choupal	2000	ITC limited, private funding agency (profit sector)	West, North, South	Private
73	FRIENDS	2000	Govt. of Kerala	South	Govt.
74	Village Information Kiosks, Andhra Pradesh	2000	MANAGE, Hyderabad	South	Govt.
75	Card (Centre for Agriculture and Rural Development)	2000	CARD	India	Govt.
76.	Samaikya Agritech Pvt. Ltd.	2000	A private sector initiative with extant cooperative structure for infrastructure support	South	Private
77	Indian Agriculture-A Global	2000	CARD (Centre for Agriculture and Rural Development	India	Govt.
78	IndiaRuralWorld.Com	1999	CoOptions technologies limited	South	Private
79	Kudumbhashree	1999	Govt. of Kerala	South	Govt.
80	Online Integrated Computerized Systems (OICS) -Sumul Dairy	1999	Surat District co-operative Milk Union Ltd (SUMUL)	West	Govt.
81	Pravara Village IT Project (PRAGATI)	1999	KVK (Krishi Vikas Kendra)	West	Govt.
82.	Bellandur	1999	Gram Panchayat of Bangalore	South	Govt.
83	Information Village Centres of MSSRF	1998	MSSRF (M.S.Swaminathan Research Foundation)	South	NGO
84	Swayam Krishi Sangam (SKS) Microfinance	1998	Swayam Krishi Sangam	East, South West	NGO
85	Warna Wired Villages Project	1998	Warna co-operative Society	West	NGO
86	AKASHGANGA	1996	Shree Kamdhenu Electronics Pvt. ltd	West	Private
87	Deccan Development Society - Community Genebank Project	1996	Deccan Development Society (DDS)	South	Govt.
88	Computer Aided Administration of Registration Department (CARD)-Hyderabad	1996	A wholly owned and successful public sector initiative	South	Govt.
89	Tamil Nadu Women in Agriculture (TANWA)	1986	Ministry of Agriculture (GOI)	South	Govt.
90	CRISP (Computerised Rural Information System Projects)	1986	NIC	India	Govt.
91	Tara Haat – TARA Nirman Kendras	1983	Tara haat	North West	NGO
92	Tata Kisan Kendras of Tata Chemicals	1983	Tata Chemical	North	Private

Table 2: Information dissemination through mobile services (Public, Private and NGO)

S. No.	Initiative Name	Year of Initiation	Initiator	Region of Country	Organization
1	Farmer Call Centre (Kissan Call Centre)	2004	Department of Agriculture & Cooperation (DoA&C), Ministry ofAgriculture, Govt. of India	India	Govt.
2	Mobile Advisory Services by ICAR-KVKs	2008	ICAR-KVK, Babhaleshwar	Gujarat	Govt.
3	SMS Broadcast Service by KVK, Babhaleshwar	2006 V	Farm Science Centre (Krishi iigyan Kendra), Babhaleshwar	Ahmednagar District	ICAR
4	Mandi on Mobile Service by BSNL	2009	Bharat Sanchar Nigam Ltd Uttar Pradesh Agricultural Marketing Board (Mandi Parishad) and IIT-K	Uttar Pradesh	Govt

5	Market Price by SMS by Rubber Board	2010	Rubber Board of India	India	Public
6	SMS Service to Farmers by the Dept. of Agriculture, Haryana	2011	Dept. of Agril Govt. of Haryana	Haryana	Public
7	Dynamic Market Information (DMI), TNAU-C-DAC, Hyderabad	2008	TNAU &C-DAC, Hyderabad	Tamilnadu	Govt.
8	vKVK (Virtual KrishiVigyan Kendra)	2010	ICAR, IIT-K and ZPD Zone IV	UP, Uttarakhand and Karnataka	Public
9	Mobile based Agro-Advisory System in North-East India(m4agriNEI)	2012	Media Lab Asia & CAU, Barapani, Meghalaya	Meghalaya	Public
10	mKisan	2011	ILRI, CABI, Digital Green, Handygo	UP, Bihar, M P, Maharashtra Andhra Pradesh and Karnataka	Public and private
11	AGMET Services by IMD	2012	IMD & other mobile service providers RML, IKSLHandygo, State Govt. Maharashtra	Maharashtra	Public and private
12	IntelligentAdvisory System for Farmers (IASF)	2013	C-DAC, DIT, GoI, Mumbai Agriculture, Govt. of Meghalaya, Dept. of Agriculture, Govt. of Manipur; KVKs ofMeghalaya andCAU, Imphal	Meghalaya & Manipur	Public
13	Kissan Kerala	2009	Department of Agriculture, Govt. Of Kerala	Kerala	Govt.
14	Kisan Help Line	2012	Bihar Agriculture University	Bihar	Govt
15	Lifelines India	2006	One World South Asia, British Telecom & CISCO	North and Central India	Private
16	Fisher Friend	2007	MSSRF and Qualcomm, TATA Tele services, Astute System Technology	Tamilnadu	Private
17	Indian Society of Agribusiness Professionals (ISAP)- Query Redress Services (QRS)	-	ISAP and OWSA & CISCO	UP, Himachal Pradesh, MP	Private
18	IFFCO Kisan Sanchar Limited (IKSL)	2007	IFFCO and AIRTEL	India	Private
19	Reuters Market Light (RML)	2007	Reuters Group Plc.	Maharashtra and Punjab	Private
20	Farmers' Helpline by Chambal Fertilisers and Chemicals Limited	2000	Chambal Fertilisers and Chemicals Limited	Rajasthan, Punjab, UP and Haryana	Private
21	mKRISHI by TATA Consultancy Services	2009	Tata Consultancy Services	Punjab, UP, Maharashtra, AP, Tamilnadu and Rajasthan	Private
22	Nokia Life Tools	2009	Nokia and Idea Cellular	India	Private
23	KHETI (Knowledge Help Extension Technology Initiative)	2008	Sironj Crop Company (SCPCL) and UK Engineering and Physical Science Research Council	M P	Private
24	Behtar Zindagi (Better Life)	2012	Handygo	South & Central India	Private
25	Mobile based Crop Nutrient Management DecisionSupport System	-	Ekgaon Technologies Farmers Federation	Tamilnadu	Private
26	Awaaz De (Give your voice)	2010	Awaaz De Info- systems Private Limited	India	Private
27	Mrittikka	-	Grameen Social Business Limited and eKutir Social Business	Eastern India	Private
28	Fasal	2008	Intuit	Gujarat, Andhra Pradesh and Karnataka	Private

29	KRIBHCO Reliance Kisan Ltd. (KRKL)	2009 .	Krishak Bharati Cooperative Ltd Reliance Communications	-	Private
30	Videokheti	-	Microsoft Research India and Digital Green	India	Private
31	Mandi Bhav	2009	BSNL, Tata Tele Services and Impetus technologies	India	Public and private
32	Kisan Sanchar	2008	Shristi Gyan Kendra & ICAR	India	Public & Private
33	Warana Unwired	2006	Warna Sugarcane Co-operative and Microsoft Research	Maharashtra	Private
34	Mobile Multimedia Agriculture Advisory System (MAAS)	2009	TNAU, NAF, EPFPCL, DPFASL and IIT-M sponsored by ICAR-NAIP	Tamilnadu & private	Public
35	Kissan SMS Portal	2013	Govt. Of India	India	Public
36	Mahaagri SMS	2009	Department of Government of Maharashtra	Maharashtra	Public
37	aAqua Mini	-	Agrocom	India	Private
38	mFMS	2012	Department of Fertilizers, Govt. Of Inida	India	Public
39	Nano Ganesh	2008	Ossian Agro Automation	Maharashtra	Private
40	Annapurna Krishi Prasaar Seva	2012	Media Lab Asia, ICAR-NAIP, ANGRAU (KVK-Nalgonda, KVK-Vellore)	Andhra Pradesh	Public

Source: Mobile Phone Applications for Agricultural Extension in India - Saravanan and Bhattacharjee (2014)

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Forecasting of Strongyle Infections in Goats of Meghalaya by Bioclimatographs

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Introduction

Domestic goat is among the earliest animals domesticated by man and is distributed worldwide with higher concentrations in tropical areas and indry zones (Di Cerbo et al., 2010). Goatsare excellent meat producers forhuman consumption in view of its short generation intervals and the absence of religious taboos associatedwith their meat as they are rich sources of proteinand can help bridge the gap of protein malnutrition among consumers (Maingi et al., 1993). Gastrointestinal (G.I.) parasitic infections are common in goats causing considerable economic losses as a consequence of mortality in infected animals and reduced weight gain. Most common G.I. parasites are helminths and among them, Strongyle sp. is very common species.It comprises several genera of nematodes within the abomasums, small and large intestines of goat. The genera that are producing the Strongyle type of eggs are *Haemonchuscontortus*, *Oesophagostomum* sp., *Trichostrongylus* sp., *Bunostomum* sp., *Chabertia* sp., *Cooperia* sp. and *Ostertagia* sp. They have similar life cycle and produce oval, thin shelled eggs. The female passes eggs in the faeces. Usually it is difficult to identify the genus and the species of eggs by faecal sample examination. Identification to genus and species is usually performed by faecal culture and larval identification.

Most of the Strongyle sp. has negative influence on their host, associated with subclinical production losses and depressive impacts upon long term animal productivity. Of all the species *Haemonchuscontortus* is very common in goat and the main sign of disease relate to its blood feeding activity, leading to anaemia, weakness and death in heavily infected animals. Due to the high biotic potential, large burdens of *H. contortus* may develop rapidly when environmental conditions favour the free living stages and death may occur with little prior warming. Moreover, the effect of parasitism is determined by the interactions between the types of parasites present in a particular geographic area, parasite life cycle, environment including weather patterns, type of farm management and the host factors.Traditionally the worm control is typically based on frequent prophylactic treatments without considering the prevailing climate, status of infection in host and on pasture and grazing practices.Hence, knowledge of climate and its influence on life cycle of parasites is crucial in formulating the worm management programmes that provide sound protection, minimize use of anthelmintics and slow down the development of anthelmintics resistance as much as possible (Swarnkar and Singh, 2011).

Environment vsGastrointestinal Parasites

It is well known fact that development, survival and dissemination of pre-parasitic stages (eggs, larvae) of G.I. parasites are primarily influenced by weather and climate. In exogenous phase of life cycle two processes (i) development of infective larvae and (ii) survival of infective larvae are involved (Swarnkar et al., 2008).Weather is a composite of atmospheric conditions such as temperature, barometric pressure, precipitation, humidity, wind velocity and direction, sunlight, cloud cover and so forth at a particular time (Levine, 1963). It determines which nematode species can develop and infect their host at a particular place and time of a year. It also establishes the specific situation in a given area. On the other hand climate is the sum of weather conditions over a longer period of time and determines which worm species generally prevails in a locality. The local climate determines the life cycles of parasites. The environmental factors which directly influence the prevalence of G.I. parasitic infections as mentioned below.

- **(i) Temperature:** Temperature determines the speed of development and survival of the free living stages of parasites.For example, larvae may be killed above 104°F, develop optimally at 86-95°F (in 8-9 days), have delayed development for 14 days at 68-77°F, and survive without hatching for more than 30 days at 32°F (Stehman and Smith, 2004).
- **(ii) Moisture:** Moisture allows larvae to escape from faeces onto vegetation and prevents the larval stages from drying out.
- **(iii) Vegetation:**Vegetation density and height also play a role in transmission of parasites. Confluent and dense grasses provide a cooler, moisture microclimate for larvae by shielding them from sunlight.
- **(iv) Rainfall:**High parasitic infection during rainy season was observed due to increased accessibility of infective larval stages (L_3) to the host.

Parasite adapt to different environments with their own strategies. During extremes of temperature, larvae halt development and reside in the host in an arrested state and reside in the host in an arrested state (hypobiosis) until favorable environment conditions return. Some species of larvae adapt by burrowing into the ground or by staying within protective casing (Stehman and Smith, 2004). Environmental factors play avital role in the parasitic infections and the prevalence rate of infections may vary (Sharma et al., 2009). Parasitic infections is mostly transmitted by ingestion of contaminated feed, water, pastures with parasitic eggs, ova, cysts, 3rd stage larvae (L_3) etc. Therefore, taking into account the significance of the environmental factors in the prevalence of G.I. parasitic infections, bioclimatographs have been prepared for forecasting the prevalence of Strongyle infections in goats of hilly region of Meghalaya. Preparation of bioclimatographs through integration of climate and biology of parasite maycombate the menace caused by G.I. parasites. It can be used for forecasting the propogation of predominant Strongyle sp. in host and environment to reduce the anthelmintic use by systematizing the worm control programme and thereby sustain anthelmintic efficacy(Swarnkar and Singh, 2011).

Preparation of Bioclimatographs

Bioclimatographs explain the distribution in space and time of pasture nematodes and represent the first rational attempt to utilize climatic observations to explain important features of epidemiology of helminthic diseases(Swarnkar and Singh, 2011). Bioclimatographsare useful in predicting the periods that are suitable for translation of exogenous stages of Strongyle sp. in environment with resultant peak of infection in host. It also provides the possibile climatic consideration in combination with grazing practices to be taken into account in evaluating expected level of refugia and thus treatments can be avoided at times when refugia are likely to be small. Thus, integration of climate and biology of parasite in the form of bioclimatographs may strengthen our tool box in combating the menace caused by G.I. parasites(Swarnkar et al., 2008). Earlier Laha et al. (2013) reported Strongyle (67.53%) infections in goats from hilly region of North Eastern India. They also predicted *H. contortus*infection in goat farm from April to September by bioclimatographs. Coproculture of goat faecal samples revealed the presence of *Haemonchuscontortus*(73.16%), *Oesophagostomum* sp. (17.68 %) and *Trichostrongylus* sp. (3.08%) larvae. Das et al. (2017) also reported Strongyle sp. (32.63%) infection in goats of hilly region of Meghalaya. Coproculture of goat fecal samples revealed the presence of *Haemonchuscontortus* (72.16%), *Oesophagostomum* sp. (14.41%) and *Trichostrongylus* sp. (4.50%) larvae.

Based on the epidemiological studies of G.I. parasites of goats in RiBhoi districts of Meghalaya, bioclimatographs have been prepared for *Haemonchuscontortus*, *Trichostrongylus* sp.and *Oesophagostomum* sp. (Fig.1, Table 1).The data pertaining to average maximum temperature, minimum temperature, total monthly rainfall and average relative humidity were obtained for the period of study from Indian Meteorological Department, Borjhar, Assam. To visualize the effect of temperature, rainfall and humidity, bioclimatograph were prepared in which total rainfall (TRF) or relative humidity (RH) is plotted

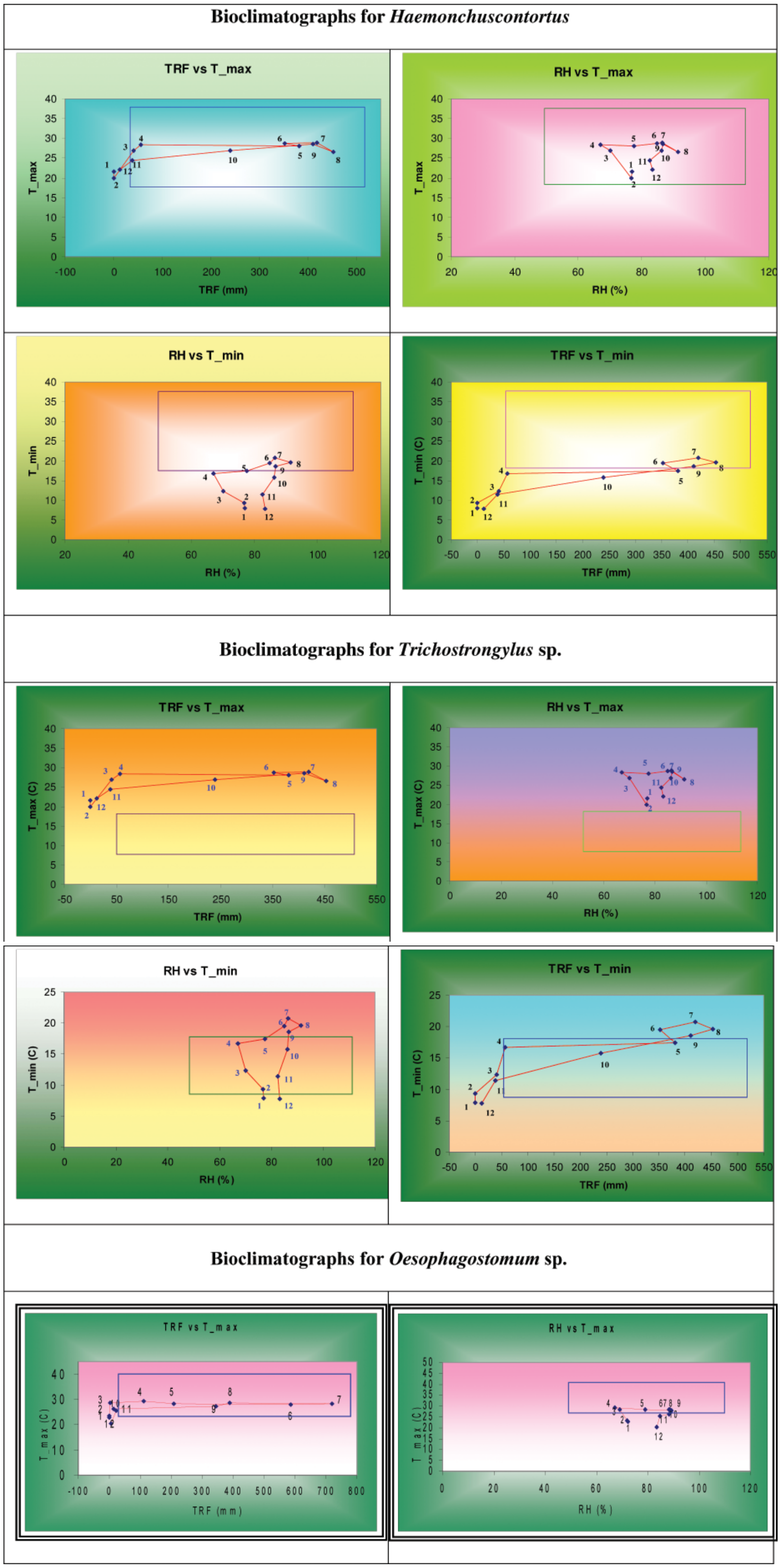

Fig. 1 Bioclimatographs for forecasting of Strongyles infections in goats of Meghalaya

against the maximum temperature (T_max) or minimum temperature (T_min) for the month and the resultant points are joined by a closed curve. On these bioclimatographs, lines indicating the limit of the climatic conditions most suitable for development and survival of exogenous stages of G.I. nematodes were superimposed and then resultant bioclimatographs were compared with the real time incidence/faecal egg count (FEC) of the G.I. parasites. To record the monthly FEC of Strongyle infection, faecal samples from goats were collected regularly at monthly intervals and assessed quantitatively by modified McMaster techniques (MAFF, 1986).The limits of suitable climatic conditions were taken as total monthly rainfall (mm), relative humidity (%) more than 50 with average monthly maximum temperature ranging from 18-37°C for *Haemonchuscontortus* and same rainfall and humidity with temperature ranging from 7 to 18°C for *Trichostrongylus* sp. For *Oesophagostomum* sp., the limits of suitable climatic conditions were taken as total monthly rainfall(mm), relative humidity (%) more than 50 with average monthly maximum temperature ranging from 25-40°C.

Conclusion

The present study revealed that bioclimatographs can be used for forecasting of Strongyle sp. infections in goats of Meghalaya.

Table 1: Comparison of Favourable months vs Observed months forStrongyle infections in goats of Meghalaya

Sl. No	Parameters of bioclimatograph	Strongyle sp.	Favourable months predicted by bioclimatograph	Observed months for higher incidence Strongyle sp.	Observed months for higher mean FEC
1	T_max v/s TRF	*Haemonchuscontortus*	Mar- Nov	Apr - Sep	May – Sept
2	RH v/s T_max	*H. contortus*	Jan – Dec	Apr - Sep	May – Sept
3	RH v/s T_min	*H. contortus*	May - Sept	Apr - Sep	May – Sept
4	TRF v/s T_min	*H. contortus*	Jun - Sept	Apr - Sep	May – Sept
5	T_max v/s TRF	*Trichostrongylus* sp.	Nil	Apr - Sep	May – Sept
6	RH v/s T_max	*Trichostrongylus* sp.	Nil	Apr - Sep	May – Sept
7	RH v/s T_min	*Trichostrongylus* sp.	Feb- MayOct- Nov	Apr - Sep	May – Sept
8	TRF v/s T_min	*Trichostrongylus*sp.	Apr- May	Apr - Sept	May – Sept
9	TRF vsT_max	*Oesophagostomum* sp.	Apr - Sept	Jun-Sept	May –Sept
10	RH vsT_max	*Oesophagostomum* sp.	Mar -Sept	Jun -Sept	May –Sept

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National Mission for Sustaining the Himalayan Ecosystem (NMSHE) Task force- 6 (TF-6): Himalayan Agriculture

For support in conducting the National Seminar on "Smart farming for enhancing input use efficiency, income and environmental security" (SFEIES) during 19th to 21st September, 2017

Project title: Sustainable agriculture for food nutritional and ecological security and for ameliorating climate change impacts in the Indian Himalayan Region (IHR).

Broad Subject: National Mission for Sustaining the Himalayan Ecosystem
Sub-area: Agriculture

Principal Investigator (PI)/Nodal Officer for NEH Region: **Dr. S.V Ngachan (Director)**
Task Force Coordinator (NEH Region): **A. Arunachalam (Principal Scientist)**
Project Duration: **5 years**

Background

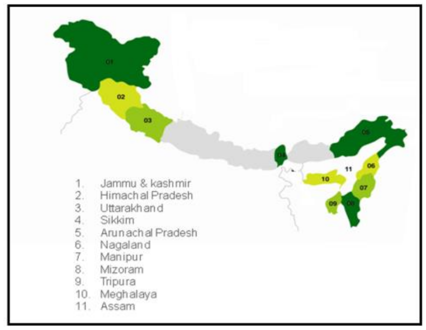
The National Mission for Sustaining the Himalayan Ecosystem **(NMSHE)** is one of the eight missions under the National Action Plan on Climate Change **(NAPCC)**. NMSHE is the only mission under NAPCC with a geographic focus, all the others being theme based. The Department of Science and Technology (DST), Ministry of Science and Technology is coordinating the implementation of NMSHE. NMSHE's action plan was approved by the Union Cabinet in 2014.

To sustain the ecological landscape of the Himalayan region the NMSHE has been commenced with active participation of ICAR Research Complex for NEH Region, Umiam and its regional centres and National Research Centres (NRC) on Yak, Pig and Mithun. The aim is to assess the vulnerability of Himalayan agriculture; to identify critical vulnerabilities of low input agricultural agro-ecosystems of the Indian Himalayas; to identify suitable measures which may be propagated within the Himalayan farming community.

Partnering Institutions:

1. ICAR Research Complex for North East Hill (NEH) Region, Umiam, Meghalaya (Lead centre) and its centres at Arunachal Pradesh, Nagaland, Manipur, Tripura, Mizoram and Sikkim.

2. National Research Centre (NRC) on Yak, Dirang, Arunachal Pradesh.
3. NRC on Mithun, Medziphema, Nagaland.
4. NRC on Pig, Guwahati, Assam.



Knowledge Partnering Institutions:

1. Indian Institute of Soil and Water Conservation, Dehradun, Uttarakhand.
2. Central Agroforestry Research Institute, Jhansi, Uttar Pradesh.
3. Directorate of Cold Water Fisheries, Bhimtal, Uttarakhand.
4. National Bureau of Plant Genetic Resources, Regional station - Umiam, Meghalaya.

Objectives

- ❖ Development of a database repository on soil (fertility and erosivity), water, genetic resources (arable crops, horticulture, agroforestry, livestock, and cold-water fisheries), socioeconomics and farmers' practices.
- ❖ Identification and promotion/scaling up of suitable practices for conserving soil, water, and vegetation focussing on carbon sequestration model to attract and flow green bonus towards the farming community.
- ❖ Validation of the extant technologies and refinement of farming systems and practices to cope with climatic variability and climate change.
- ❖ Capacity building of farmers for a low carbon future through climate resilient agricultural practices including popularization of suitable farm machinery.
- ❖ Assessment of the potential of agroforestry and conservation agriculture to mitigate climate change impacts.


For further information please contact Dr. S.V. Ngachan, Director ICAR Research Complex for NEH Region, Umiam Meghalaya. Phone: 0364-2570257(O), Fax: 0364-2570355

Email: svngachan@rediffmail.com

Our Sincere Thanks to:

Indian Association of Soil and Water Conservationists (IASWC), Dehradun

For support in conducting the National Seminar on "Smart farming for enhancing input use efficiency, income and environmental security" (SFEIES) during 19th to 21st September, 2017

About the (IASWC), Dehradun

The Indian Association of Soil and Water Conservationists (IASWC) was established in 1972 at Dehradun, as a non-profit making body to encourage wise land use planning and conservation of soil and water resources so that these basic resources can be utilized to sustain mankind. The utilization of both, the renewable and non-renewable resources of the country is primarily the responsibility of scientists and conservation professionals, who understand the natural ecosystem processes and also of policy makers who make laws that influence the use and misuse of the basic resources of soil, water and vegetation. The Indian Association of Soil and Water Conservationists resorts itself through its members to serve as a forum of scientists, conservation professionals, administrators and policy makers in assessing the need for soil and water conservation and watershed management.

Aims and Objectives:

- To promote and disseminate the knowledge, practice and research in the science and technology of Soil and Water Conservation.
- To encourage free exchange of ideas amongst those contributing to the advancement of Soil and Water Conservation such as Agronomists, Agrostologists, Ecologists, Engineers, Foresters, Geologists, Land Users and Soil Scientists etc. by organizing symposia, lectures and bringing out literature etc.

The affairs of the Association are managed by an Executive Council in accordance with the Constitution of the Association. The council consists of President, Vice Presidents, Chief Editor, Secretary, Joint Secretary, Treasurer, Business Manager and Members. The normal term of each elected member of the Council is 2 years.

Members:

All persons engaged directly or indirectly in any aspect of soil and water conservation and any institution, society etc., engaged in this regard can become members of the Association. In addition, honorary members are elected from amongst eminent persons in the field of natural resource conservation. Election of the honorary members is governed by the byelaws framed by the Executive Council and approved by the General Body. **Till date, The IASWC has 2174 life members, 50 Institutional members and 35 ordinary members.**

Activities of the Association

Publication of Indian Journal of Soil Conservation: During the last four decades, the Indian Journal of Soil Conservation (IJSC) made its journey starting in humble beginning during 1973 as a Soil Conservation Digest (Vol.1 (1973) to Vol. 5 (1977). It was renamed as Indian Journal of Soil Conservation w.e.f. Vol.6 (1978). The papers published in the Journal initially in first two decades covered the topics on appraisal on erosion hazards, soil erosion maps of different states of the country followed by the erosion losses, processes, studies and measures to control erosion etc. With the advancement of the time, the journals covered its onward journey with the papers on diverse and timely topics viz., farming system research, degraded land management, agroforestry and land use planning and remote sensing in relation to natural resource conservation and the scope of the journal broaden. The journal published by the IASWC is peer reviewed and is critically edited for its quality and contents. From 1973 till date (August, 2017) the IASWC has published 45(2) volumes covering research papers on various themes.

Online Publication of IJSC: Online publication of IJSC was initiated from March, 2010 and presently all the issues are available online with indianjournals.com upto Vol. 44(2), 2015.

Our Sincere Thanks to:

Network Project On Organic Farming (NPOF)

For support in conducting the National Seminar on
"Smart farming for enhancing input use efficiency, income and environmental security" (SFEIES)
during 19th to 21st September, 2017

NETWORK PROJECT ON ORGANIC FARMING (NPOF)

- In view of negligible use of agro-chemicals, high availability of biomass, crop residues, livestock excreta based manure, high soil organic carbon etc. the north eastern region (NER) of India has very good opportunity for organic farming.
- NOPOF was initiated during 2005 to undertake basic and applied research on various aspects of organic farming in NER.
- The project is funded by ICAR-IIFSR, Modipuram.
- The results of 12 years study revealed that most of the crops recorded significantly higher productivity under organic followed by integrated management practices.

- Soil health also improved over the years under organic relative to inorganic practices.
- Most of the produce quality parameters also are better under organic than others.
- Two integrated organic farming system (IOFS) models have been developed by the Institute for valley and sloping lands for impro productivity and livelihood of farmers.

- Institute is conducting training and demonstrations on organic farming for researchers, extension functionaries and farmers.
- Institute adopted 3 villages in Meghalaya since 2013 covering about 350 farmers for demonstration of organic farming technologies developed by the Institute.
- Institute has developed package of practices for important cropping systems of the region.
- Working in close collaboration with Department of Agriculture and other Depts. of North Eastern states.
- For further information, please contact director, ICAR Research Complex NEH Region, Umiam, Meghalaya.

NICRA

National Innovations in Climate Resilient Agriculture

NICRA **aims at tackling multiple biotic and abiotic stresses on crops, livestock and natural resources.**

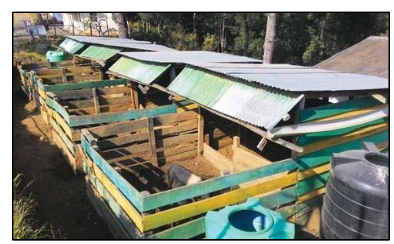
Objectives:

- **Identification of temperature, drought and other stress tolerant varieties/breeds of crops/livestock/fish for north eastern hill ecosystem.**
- **Development of adaptation and mitigation strategies through soil and water management practices for climate resilient agriculture.**
- **Understanding and exploiting the climate-ready traits in pig and poultry and development of data base.**

Initiative taken under NICRA:

- **Selection and development of promising crop genotypes and livestock breeds with greater tolerance to climatic stress.**
- **Demonstration of existing technologies for climate resilient agriculture in vulnerable areas.**
- **Strengthening research infrastructure for climate change studies.**
- **Development of adequately trained human resource to take-up climate change research in the region and empowerment of farmers to cope with climatic variability.**






ICAR Research Complex for North Eastern Hill Region, Umiam-793103, Meghalaya

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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch

TRIBAL SUB PLAN
Government of India

भा कृ अनुप - पु प सं
ICAR - RCNEH

A comprehensive strategic approach for the welfare and development of STs in the country

Objective :

- Substantial reduction in poverty and un-employment.
- Creation of productive assets in favour of Scheduled Tribes to sustain the growth likely to accrue through development efforts.
- Human resource development of the Scheduled Tribes by providing adequate educational and health services, and
- Provision of physical and financial security against all types of exploitation and oppression

Livelihood Improvement in North East under TSP programme

ICAR Research Complex for North Eastern Hill Region, Umiam-793103, Meghalaya

With Best Complements from:

NATIONAL BANK FOR AGRICULTURE AND RURAL DEVELOPMENT

National Bank for Agriculture and Rural Development
Upheit Kharmiphen Building 2nd & 3rd Floor,
Meghalaya - 793003. Shillong

Our Sincere Thanks to:

ICAR Research Complex for NEH Region, Umiam

For support in conducting the National Seminar on
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during 19th to 21st September, 2017

Our Sincere Thanks to:

Central Agricultural University, Imphal

Our Sincere Thanks to:

Assam Agricultural University, Jorhat, Assam

With Best Complements from

State Bank of India, ICAR Complex Branch, Umiam

Our Sincere Thanks to:

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH

For support in conducting the National Seminar on

"Smart farming for enhancing input use efficiency, income and environmental security" **(SFEIES)**

during 19th to 21st September, 2017

OUR SINCERE THANKS TO:

North Eastern Council

NEC Secretariat,
Nongrim Hills,
Shillong-793003

We duly acknowledge

Ms. Excel International Proprietor panka

For support in conducting the National Seminar on
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(SFEIES)
during 19^{th} to 21^{st} September, 2017

We duly acknowledge

M/s Sun Scientific Store

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(SFEIES)
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We duly acknowledge

M/s UPL Limited

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(SFEIES)
during 19th to 21st September, 2017

We duly acknowledge

M/s D S Enterprise

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during 19th to 21st September, 2017

We duly acknowledge

Agri-Business Incubator (ABI)

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We duly acknowledge

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during 19th to 21st September, 2017

We duly acknowledge

Eastern Marketing

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(SFEIES)
during 19th to 21st September, 2017

WE DULY ACKNOWLEDGE WISHES FROM VARIOUS

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National seminar
On
'Smart Farming for Enhancing Input Use efficiency, Income and Environmental Security (SFEIES 2017)" 19-21 Sept, 2017, Umiam (IAHF & ICAR RC NEH)

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All the chairman and conveners may organize their respective committee meeting for successful organization of the event.

(SV Ngachan)
Director, ICAR RC NEH & President, IAHF

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