

The case for agriculture as a strategic solution to climate change in rural areas.

Strategies for Combating Climate Change in Drylands Agriculture

- Reducing vulnerability and increasing productivity for rural communities
- Climate smart solutions for smallholder farmers

Synthesis of dialogues and evidence presented at the International Conference on Food Security in Dry Lands, Doha, Qatar, November, 2012

Changes in climate patterns are having their most acute effect on people living in the world's dry areas and marginal lands. As these rural communities are largely dependent on agriculture for their livelihoods, it follows that improvements in agricultural research and 'integrated agro-ecosystem' approaches are probably the primary protection from climate related problems. This is also why agricultural innovation, research, technology transfer and capacity building should be strategic priorities of the UNFCCC.



RESEARCH PROGRAM ON
Climate Change,
Agriculture and
Food Security



International Center
for Agricultural Research
in the Dry Areas



RESEARCH
PROGRAM ON
Dryland Systems



برنامج قطر الوطني للأمن الغذائي
QATAR NATIONAL FOOD SECURITY PROGRAMME

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a strategic partnership of CGIAR and the Earth System Science Partnership (ESSP) led by the International Center for Tropical Agriculture (CIAT). CCAFS brings together the world's best researchers in agricultural science, development research, climate science and Earth System science, to identify and address the most important interactions, synergies and trade-offs between climate change, agriculture and food security. www.ccafs.cgiar.org.

The International Center for Agricultural Research in the Dry Areas (ICARDA) is the global agricultural research center working with countries in the world's dry areas, supporting them for the sustainable productivity of their agricultural production systems; increased income for smallholder farmers living on dry lands and in fragile ecosystems, and nutrition and national food security strategies. With partners in more than 40 countries, ICARDA produces science based-solutions that include new crop varieties (barley, wheat, durum wheats, lentil, faba bean, kabuli chickpea, pasture and forage legumes); improved practices for farming and natural resources management; socio-economic and policy options to support countries to improve their food security. ICARDA works closely with national agricultural research programs and other partners worldwide – in Central Asia, South Asia, West Asia, North Africa, sub-Saharan Africa.

The CGIAR Research Program on Dryland Systems brings together a wide range of partners, including countries, research and development organizations to bring rural communities living in the world's dry areas practical solutions for improved livelihoods and food security. The goal of Dryland Systems is to identify and develop resilient, diversified and more productive combinations of crop, livestock, rangeland, aquatic and agroforestry systems that increase productivity, reduce hunger and malnutrition, and improve quality of life among the rural poor. To develop solutions, research teams - in partnership with rural communities and countries - will validate the effectiveness of interventions in representative agro-ecosystems, and promote their scaling-out in the dry areas of five target regions: West Africa Sahel and the Dry Savannas; East and Southern Africa; North Africa and West Asia; Central Asia and the Caucasus.

CGIAR is a global agriculture research partnership for a food secure future. Its science is carried out by the 15 research centers who are members of the CGIAR Consortium in collaboration with hundreds of partner organizations. www.cgiar.org

Qatar National Food Security Program's mission is to develop a comprehensive and sustainable long-term solution to the food security challenges faced by the State of Qatar. The objective is to increase domestic agricultural production and strengthen the security of food imports to alleviate the food supply deficit that the country faces. The programme can also serve as a model to other dry land countries in the region and globally. It will implement the use of solar energy to desalinate seawater, for its agricultural production and develop Research & Development centres, educational facilities, and introduce technologies that enable Qatar to diversify its economy while preserving its natural resources to ultimately achieve Food Security.

Reporting and writing: Clare Pedrick. Compiled by Michael Devlin (ICARDA), Torben Timmermann (CCAFS).

Copyright and Fair Use

Creative Commons License: This Report is licensed under a Creative Commons Attribution – NonCommercial-NoDerivs 3.0 Unported License. This publication may be freely quoted and reproduced provided the source is acknowledged. No use of this publication may be made for resale or other commercial purposes.

ISBN - 92-9127-291-4

Copyright ICARDA/CCAFS 2012.

Strategies for Combating Climate Change in Drylands Agriculture



RESEARCH PROGRAM ON
Climate Change,
Agriculture and
Food Security



International Center
for Agricultural Research
in the Dry Areas



RESEARCH
PROGRAM ON
Dryland Systems



برنامج قطر الوطني للأمن الغذائي
QATAR NATIONAL FOOD SECURITY PROGRAMME

Contents

Executive Summary

1. Dryland Agriculture – a core issue for climate change	1
2. Strategies and best practices Land and water, crops and livestock	5
2.1 Sustainable intensification for high potential land, more resilience for marginal lands	5
2.2 Genetic improvement – more productive crop varieties and livestock breeds	6
2.3 Diversification -- spreading the risk to earn higher revenues	8
2.4 Integrated crop-livestock systems. Crops or livestock. Why not both?	8
2.5 Conservation agriculture produces more for less	8
2.6 Getting innovations into farmers fields - examples of technology uptake in seven drylands countries.	10
2.7 Better water management. The key to sustainable food production in dry lands	11
3. Climate change interventions.	
3.1 New problems need new solutions.	15
3.2 Climate smart options	15
3.3 Capturing carbon	15
3.4 Climate initiatives	16
4. Agricultural research. Strengthening agricultural innovation systems through research, education and extension	17
4.1 Technical solutions	17
4.2 Policy. The right environment	17
4.3 National and regional	17
4.4 Extension. Pass it on	17
4.5 Investment. Good returns	18
4.6 Working together	18
4.7 North-South, South-South	18
5. Reading list	20
6. Annexes	21

About this report

The aim of this report is to examine the problem of changing climate patterns in dry land areas and its effect on rural populations and offer some practical solutions, as input the Conference of Conference of the Parties (COP18) United Nations Framework Convention on Climate Change (UNFCCC)

It has been prepared to inform government policy makers and agricultural planners in dryland countries, and development partners, of the issues at stake and present options available to reducing risk and increasing productivity of agriculture in drylands agricultural systems.

The information presented here comes from discussions at the International Conference on Food Security in Dry Lands, held in Doha, Qatar, on Nov 14-15, 2012. It is informed by the body of agricultural research produced by three authors of this report:

- CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)
- ICARDA – The International Center for Agricultural Research in the Dry Areas
- CGIAR Research Program on Dryland Systems

The Doha conference brought together a large number of dryland government ministers with researchers, policy makers, donors, NGOs, farmers' unions and private agribusiness enterprises to explore the challenge of increasing agricultural production in dry countries, under conditions of severe water scarcity and climate change.

The ministers' recommendations, resulted in the Doha Declaration (see Annexe), which is taken forward on behalf of the Dry Lands to the 18th session of the Conference on Parties of the UN Conference of Parties of the Convention on Climate Change (COP 18), which opened in Doha in November 2012.

Executive Summary

Risks and opportunities for dry land agriculture. New solutions to tackle climate change

The added-value that agriculture and agricultural research brings to the United Nations Framework Convention on Climate Change

Changes in climate patterns have the most acute effect on people living in the world's dry areas and marginal lands. As these rural communities are largely dependent on agriculture for their livelihoods, it follows that research innovations provided by agricultural research and improved 'integrated agro-ecosystem' farming approaches are probably the primary protection for these people from climate-related shifts. This is also why agricultural innovation and research should be recognized as strategic priorities of the United Nations Framework Convention on Climate Change (UNFCCC)

The evidence presented in this report shows that many of the most effective climate change interventions have their roots in agriculture. Targeted agricultural investment in spreading the technologies and practices described here, and backed up by robust policies, can reduce the vulnerability of farming communities to drought and climate change and sustainably improve agricultural productivity.

Against a backdrop of increasing climate change, a primary challenge for decision makers in the world's dry lands will be helping rural communities to earn a living and produce food securely in a situation where land is degraded, water scarce, and rainfall and temperature patterns increasingly unpredictable.

Viable options and interventions exist today. They include using: improved crop varieties and livestock breeds; farming approaches to reduce risk and improve nutrition; making farming for communities living in on marginal lands more resilient; and methods for making the best possible use of the scarce water available. Approaches such as diversification of cropping systems, more efficient water management and conservation agriculture can contribute to securing livelihoods for rural people and increasing food security for the dry land countries.

Likewise, 'climate smart' strategies and technologies will have an important role to play in helping producers to adapt to changing weather patterns and adopt more sustainable farming methods that protect fragile natural resources. Given the importance of agriculture to dryland countries, where farming is still the backbone of the economy, it is crucial that this sector receives the investment and policy support it needs to move forward.

If farmers are given the chance to seize the opportunities available, they can increase food production to keep pace with the growing population and reduce the need for costly food imports. To achieve this goal, they must change some of their practices and embrace new methods, while continuing to preserve some of the most effective systems handed down through generations.

Projections from the recently launched CGIAR Research Program on Dryland Systems suggest that planned interventions will result in higher and more secure incomes for 87 million people in dryland systems, while improving the productive capacity of natural resources and reducing environmental degradation in nearly 11 billion hectares of dry areas.

Within six years, agriculture productivity and production can be increased by 20 to 30% in high potential areas and 10 to 20% in low potential areas or marginal lands. Out-scaling of proven technologies will cover a far wider area and improve the standard of living of a much larger population.

Strong agricultural adaptation measures are the key to developing food production in dry lands, but these are contingent on policy and financial support. Since agriculture holds so many of the answers to challenges posed by changing weather patterns, it makes sense that this sector takes center-stage in climate change negotiations.

Agriculture holds the key to many dry land problems. Urgent action in favor of agriculture will help build food and water security and mitigate the negative effects of climate change.

Key problems facing dryland countries:

- Food production systems in dryland countries are highly fragile
- Some 16% of the population of dry lands live in poverty
- Food imports are untenably high
- Water scarcity is a constant and growing problem
- Adverse climate events (extreme heat and cold; drought and flooding) are aggravating vulnerability

Proposed solutions:

- Securing more resilience and reducing vulnerability of people living in marginal lands
- Achieving sustainable intensification of higher-potential agricultural areas
- Improved crop varieties and livestock breeds
- Integrated crop-livestock systems
- Conservation agriculture
- Diversification of food production systems
- Natural resource and especially water management
- More agricultural research and investment
- Climate smart agriculture initiatives
- Greater focus on the potential of agriculture in climate change negotiations
- Taking an integrated agro-ecosystem approach to these actions.

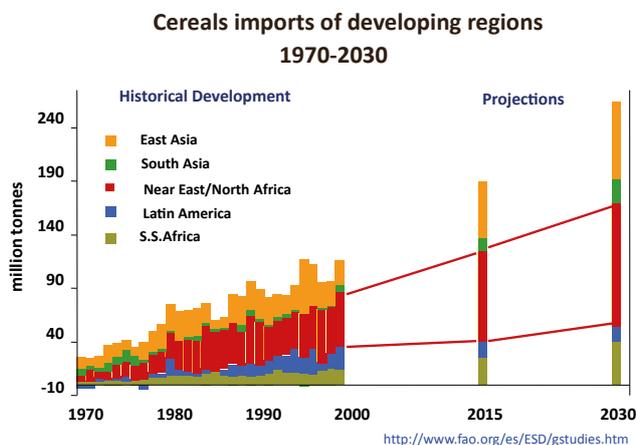
1. Dryland agriculture – a core issue for climate change

Risks posed by degraded land and scarce water resources

Dry areas cover more than 40% of the world's land surface and are home to 2.5 billion people – one-third of the global population. Poverty, food insecurity, biodiversity loss, frequent drought and environmental degradation are widespread. In recent decades, food production has fallen significantly in most dry areas, while demand has increased due to high levels of population growth. These areas face several demographic challenges – rapid population growth, high urbanization, large youth populations and among the world's highest unemployment rate.

Climate change is already exacerbating these countries' problems, and experts predict that the situation is going to get worse.

The global food crisis of 2007/8 and subsequent price hikes have highlighted the danger of policies based on food imports. The dryland areas have a strong reliance on imported food, especially wheat, which is a staple product and which suffers from substantially lower yields than those of many other regions – up to 30% below the global average.



The Near East and North Africa is the world's highest food deficit region.

Taking the example of cereals for current and projected food needs, the region will continue to be the planet's largest cereals importer, following current practices.

Scarce water availability limits food production

Water scarcity is a constant and growing problem for dryland countries. The dry lands have less than eight per cent of the world's renewable water resources and are challenged by extreme temperatures, frequent drought, land degradation and desertification.

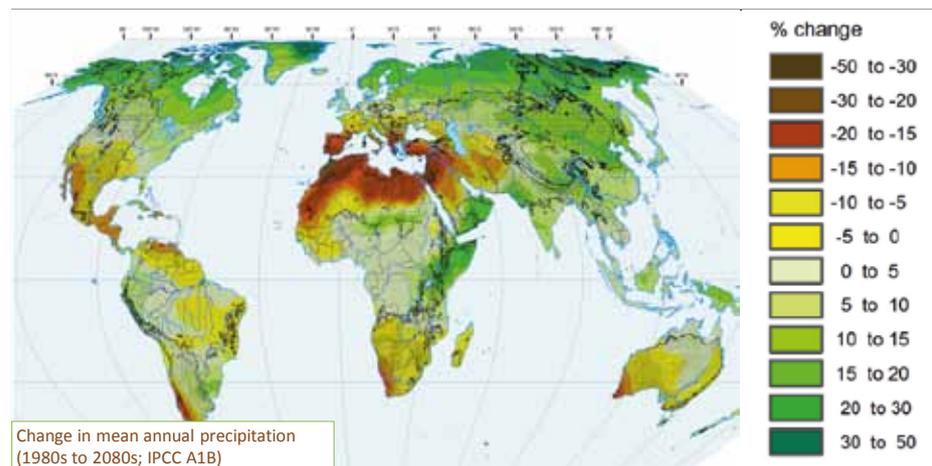
Across all dryland areas, scarce water availability is the key limiting factor for food production. All these countries are suffering from severe groundwater depletion and salinity, compounded by rapid natural resource degradation and desertification. The Middle East and North Africa is the most water scarce region in the world, and the problem is set to deteriorate.

Famines and disasters have hit dry lands with increasing intensity and have, together with spikes in food prices, led to political unrest in many countries. With climate change, such events may become even more frequent.

Climate change takes a high toll on agriculture

There is a strong link between food security, climate change, water security and poverty and agriculture plays a key role in the equation. Agriculture is highly vulnerable to climate change. Unreliable precipitation patterns increase the likelihood of crop failure and falls in production of both crops and livestock. In many dryland countries, the effects can already be seen as climate change makes the delicate ecosystem balance even more precarious.

There is a strong link between food security, climate change, water security and poverty. Agriculture plays a key role in this equation.



Change in mean annual precipitation (1980s to 2080s; IPCC A1B)

Under climate change, dry lands will increase significantly in area, and conditions for agriculture in dry lands will decline considerably, especially in regions already affected by poverty and food insecurity.

Major decreases of rainfall are expected in MENA and southern African dry lands, Australian, North America. Increases in rain are expected in the dry lands of East Asia dry lands.

This is IPCC scenario A1B average of 21 GCMs

Farmers and other players in food production value chains can make key contributions to sustainable food and water security, provided they have access to technologies and support to help them adjust their practices to address changing weather patterns.

Climate change is causing more frequent and intense periods of drought as overall rainfall levels decline. Temperatures are more extreme – both hot and cold - and climatic zones are shifting. This results in shorter growing seasons for farmers and in prevalence of pests and diseases in areas where they were not previously a threat to crops. If temperatures rise by 4 degrees Celsius, as forecast by some climate change models, vast areas of dry lands will have their growing seasons cut by more than 20%.

Access to food is also threatened, and there are fears that this will be further compromised in dryland areas due to lower incomes and the emergence of new pests and diseases caused by a changing climate. In dryland countries that are already geopolitically volatile, such developments could have a serious impact on social and political stability.

Climate initiatives and climate smart technologies.

Without vigorous adaptation measures, use of new practice and technologies – and policies and financing to support them, there can be little hope of reaching poverty alleviation and food security goals. Farmers and other players in food production value chains can make key contributions to sustainable food and water security, provided they have access to technologies and support to help them adjust their practices to take account of changing weather patterns. Climate initiatives and 'climate smart' technologies can help increase food production for a growing population, while safeguarding precious natural resources.

Adaptation measures not only improve food security. They can also contribute to reducing the impact of climate change by lowering greenhouse gas emissions from agriculture. Agriculture is a major contributor to climate change, through deforestation for land cultivation, methane emissions from livestock production and unsustainable practices in food production systems. The sector is also the biggest user of the world's freshwater resources – up to 90% in some countries.

Many of the answers to the problems faced by people in drylands regions exist today. But technologies and practices need scaling-up – through technology transfer and training, advocacy to decision makers in countries and development agencies. But none of this can happen without an enabling policy environment, that is created by affected countries to ensure that the most effective innovations are put into action and that long term funding and investment is available.

Agriculture and the climate change agenda

Experts involved in rural development increasingly agree that any strategies for climate change must include agriculture. All the evidence points to the fact that the impact of climate change on development in rural areas will be severe, especially in dry lands. But though agriculture is a key issue for climate change, it risks being sidelined in upcoming talks on climate change, as it has been in previous Convention on Climate Change (COP) negotiations.

In the run up to the 18th session of the UN Conference of Parties for the Convention on Climate Change (COP 18), there were calls for more focus on agriculture in the negotiations. A detailed treatment of agriculture has yet to enter any of the agreements linked to the United Nations Framework Convention on Climate Change (UNFCCC).

UNFCCC and agriculture

The next round -- COP18

The COP 18 talks, in Doha, Qatar, from Nov 26 to Dec 7, represent an important opportunity for countries with extensive dry lands to shape the global climate agenda and ensure that food security receives attention in the negotiations.

Climate change adaptation is a costly process, and if dry areas are to maintain – or increase – food production under these conditions, it is essential that they are able to tap into any funding made available. The prospect of agriculture continuing to be bypassed in negotiations carries the risk that the sector will lose out on substantial funding for climate change. The Green Climate Fund has a target of US\$100 billion by 2020. The fund will be used to limit or reduce greenhouse gas emissions and to adapt to the impacts of climate change.

Current state of play: Agriculture's place in the UN Climate Change Framework

As things stand, agriculture has been all but excluded from international negotiations on climate change. However, some progress has been made in achieving more focus for agriculture in the UNFCCC agenda. At COP 17, held in Durban in December 2011, with vigorous support from host country South Africa, agriculture was specifically mentioned in the UNFCCC text for the first time. A small victory perhaps, but a significant step in the right direction.

Specifically, at COP 17, there was:

- High level support for inclusion of agriculture
- Wide support, e.g. across Africa and in OECD countries, for agriculture (though perspectives differed on how to deal with it in the negotiations).
- Agriculture graduated from "Long-term Co-operative Actions" (LCAs) to the "Subsidiary Body for Scientific and Technical Advice" (SBSTA)
- A call for submissions on an agriculture work-plan under SBSTA.

The next stage will be establishing a SBSTA agenda for agriculture – a work program on agriculture. This should provide the evidence and methods to achieve development goals of mitigation, improved food security and more resilient livelihoods and where feasible, mitigation. SBSTA has been mandated to consider issues related to agriculture and to prepare a decision to be adopted at COP18 in Qatar.

Although there have been divergent views of countries regarding adaptation and mitigation approaches, submissions to date have shown a high degree of consensus on the need for a programme of work to include:

- Better information on agriculture and climate change - knowledge on both adaptation and mitigation, including lessons from the developing world
- Dissemination and use of knowledge to improve farming practices: so as to: increase outputs adapt to changing conditions and reduce emissions.

Moving agriculture further up the climate change agenda

Interview:

Prof. Thomas Rosswall, chairman of the CGIAR Independent Science Panel for the CGIAR Research Program on Climate Change Agriculture and Food Security (CCAFS).

How is agriculture linked to climate change?

"Agriculture is part of the problem, but it is also part of the solution. Agriculture - and its impact on deforestation - account for one-third of greenhouse gas emissions. So better agricultural practices are very important for mitigating climate change. Agriculture is also one of the sectors that will be hardest hit by climate change. In the dry lands, additional decreases in rainfall and more drought will exacerbate an already very difficult situation."

So what needs to be done?

"Agriculture can contribute to mitigation, by intensifying current land to avoid deforestation and other land use changes. By increasing storage of carbon in vegetation and soil, and by reducing methane and nitrous oxide emissions. These factors also contribute to adaptation and create a win-win situation."

What about adaptation for dryland farmers?

"Small-scale farmers have so far had very little opportunity to adapt. Climate change adaptation will be very costly for agriculture. It is absolutely essential that the agriculture sectors receives a share of funding available."

How can funding be channeled to the agriculture sector?

"Climate financing is essential and 10% of national budgets must go to agriculture and food security. Countries driving greenhouse gas emissions must also pay. The Green Climate Fund must reach its US\$100bn target by 2020. COP 18 offers a unique opportunity for governments to ensure that food security gets attention in the negotiations."

How do you see agriculture's position in the current climate change negotiations?

"We made some progress at Durban when, for the first time, agriculture was specifically mentioned in the text. South Africa pushed very hard. Dryland countries should ensure that agriculture is part of the UNFCCC discussions. A work programme on agriculture should be established. Without agriculture, there should be no deal."

2. Strategies, technologies and best practices

Land and water, crops and livestock

The situation is serious, but certainly not hopeless. With more targeted research and investment, there are good prospects for reducing risk and even improving agricultural output, despite climate change. A number of practical approaches – tested in recent agricultural research initiatives – can improve prospects for farmers and rural communities.

2.1 Sustainable intensification for high potential land, more resilience for marginal lands

Improved crop varieties that can resist temperature extremes, drought and disease, different land and water management practices, diverse cropping and mixed crop-livestock systems can all bolster food security and increase incomes for rural communities. The challenge in dry areas is how to produce more with very little. To do that, it is crucial to favor crop varieties and livestock breeds that make efficient use of the natural resources available.

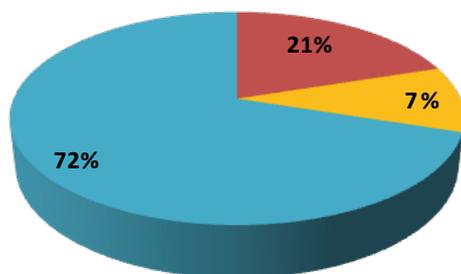
Improving efficiency, without using more land

There are two key strategies for the world's dry lands. In high potential rural areas, where there is relatively high rainfall, the target must be sustainable intensification of food production – with the accent on sustainable. Egypt is an example of this type of ecosystem. In high potential areas, 72% of increased food production is expected to come from agricultural intensification. 21% is expected to come from cropping intensity. And only 7% will come from an increase in arable land.

For the low potential marginal lands, it will be important to make the natural

Sources of Increase in Food Production & The Trend Towards Intensification of Production Systems

■ Cropping Intensity ■ Increase in Arable Land ■ Agriculture Intensification



Source FAO

The case for 'sustainable intensification': an increase in the area of arable land may only result in a 7% increase in food production. Yet this might be an optimistic figure, as the combination of unsustainable land use, over-exploitation of resources, and climate change can potentially desertify millions of hectares of arable land.

resource base more resilient to climate change, reducing risk and vulnerability for the worst affected rural communities. Food production here is likely to center around the rearing of sheep and goats, though this may be coupled with production of hardy drought resistant fodder crops. A good example is the Awasi sheep, a sturdy native breed that gives resilience to rural communities in the Middle East. Awasi offer considerable potential for use across marginal lands in many dryland countries (Central and West Asia, East and North Africa) bringing nutrition and new income streams to rural communities from milk products, wool or meat.

A three-pronged approach should target:

- Sustainable natural resource management, especially water
- Genetic improvement of crops and livestock
- Socio-economic policy and institutional support

More agricultural modernization, driven by science and technology, is key to increasing food production in dry areas.

In seven countries across North and sub-Saharan Africa, new approaches tested by national research and extension systems, with ICARDA, have produced a 22% increase in wheat yields for Egypt and a 58% increase in Sudan – based not just on trials, but on actual farmer experiences. Techniques include the use of different planting methods, high yielding varieties, improved water management and integrated pest management.

Climate change – problem or opportunity?

With sustainable intensification, climate change can actually become an opportunity to increase yields.

Climate change brings with it higher levels of carbon dioxide (CO₂). If water levels are adequate, a plant can convert this CO₂ into a form of natural fertilizer. The plant uses the carbon for photosynthesis, and grows bigger and better as a result.

2.2 Genetic improvement – more productive crop varieties and livestock breeds

Advances in crop science to produce improved and higher-performing crops and livestock hold exciting prospects for making dryland food production systems more efficient, and more resistant to pressure from drought, extremes of cold and heat, unpredictable rainfall and new pests and diseases. For optimal performance, varieties can be targeted to specific farming systems, depending on local conditions and stresses

Crop Improvement: varieties released using ICARDA germplasm worldwide, 1977 to 2011

Crop	1977 - 2011		Last 2 years
	Developing Countries	Industrialized Countries	All Countries
Barley	175	31	6
Durum Wheat	102	14	1
Bread Wheat	224	6	9
Chickpea	108	31	9
Faba Bean	51	6	1
Lentil	96	16	9
Forages	30	2	2
Peas	9	0	0
Sub-Total	761	120	
Total	881		37
Estimated Net Benefit = about US \$850 m / year			

New varieties released: More than 900 improved cereal and legume varieties have been released by national programs in partnership with ICARDA, and adopted by farmers worldwide.

Releases of plant genetic materials from ICARDA's gene banks, which host wild relatives of barley, wheat and legumes, has led to the development of crops with higher yields and greater resistance to a range of biotic stresses. Some varieties also offer large improvements in bread-making quality, nutritional value and other traits.

Tapping the potential of drylands agriculture in the face of climate change

Interview:

Dr. Mahmoud Solh, Director General of the International Center for Agricultural Research in the Dry Areas (ICARDA).

What are some of the main challenges currently facing dry lands?

"Key biophysical constraints include natural resource limitations and degradation, particularly water scarcity and encroaching desertification, in addition to salinity problems in irrigated areas. Livelihoods are also constrained by non-biophysical limitations such as inadequate and unequal access to land, water, markets and inputs and limited access to information about alternative production technologies."

Given these difficulties, what should the approach be?

"The challenges are complex, to the point where there is no silver bullet for solving these problems. But there are practical solutions available today that will increase food security. These practical solutions follow an integrated approach involving sustainable natural resource management and inputs; crop and livestock genetic improvement; socio-economic considerations - and require an enabling policy environment. Partnerships are also critical success factors, considering the complexity of the challenges facing drylands and the need for an integrated approach. Countries now need more precise action plans to follow an integrated approach and develop strategic partnerships to find solutions to increase the productivity agriculture in the dry drylands."

How much real potential is there, given the serious threat posed by climate change?

"The possibilities for improving food security in dry lands are tremendous. The two major target areas are sustainable intensification – and it is crucial to underline sustainability, without excessive use of water – and increasing resilience for marginal lands. For example, the use of 'raised bed' farming for wheat in parts of Egypt during the past two seasons has resulted in a yield increase of 20%, using 20% less water. In rangeland areas, herders are being encouraged to diversify, and to produce value-added products such as yoghurt and cheese."

How important is it to invest in scientific research for agriculture?

"Science-based agricultural technologies are a real force for increasing food security in dry areas. Unfortunately, in the developing world, many countries have not invested in science and technology for agriculture. Those countries who have invested - such as China, India and Argentina - have grown very well, but in most parts of the developing world there is the feeling that investment in agriculture does not contribute to the national economy – we need to help change this thinking."

So what can be done to mobilize more investment in agricultural research and technology?

"I think we as scientists have a very important role to play. It is important that we demonstrate the benefits and impact of agricultural research to decision makers – to ministries of agriculture but also to ministries of planning and finance. A study we have done on investment in a wheat initiative in Upper Egypt demonstrates returns of 37%. This shows what is possible, and what can be spread to others countries and regions, in a real-life farming situation."

Genetic improvement boosts livestock productivity

An initiative to improve genetic stock is boosting animal productivity and profitability in dry areas. Part of an integrated livestock technology package developed by dryland scientists, other components include animal nutrition, feed and fodder production and preventive veterinary care. Good results have been obtained for sheep and goat herders using this approach in Afghanistan and Pakistan. With some adjustments for local conditions, the strategy can be applied to other dry countries.

Documented results in these two countries reveal:

- 80% to 200% increases in meat and milk production and animal growth rate.
- Benefit: cost ratios of 3:1.
- A dramatic fall in animal mortality rates.
- In Afghanistan, the technology package generated benefits worth over US\$650,000, with a 71% rate of return on investment

Already, scientists have produced some convincing results:

More than 880 new varieties have been released for cultivation, generating annual benefits worth US\$850 million.

- Dryland researchers have developed synthetic wheat varieties that can produce 2.5 tonnes per ha with just 220 mm of water.
- Between 2005 and 2007, Syria turned from being a wheat importer to a wheat exporting country with the help of new improved plant varieties, and supplemental irrigation – which targets the critical period in crop growth – and inputs.
- In Sudan south of Khartoum, an irrigated heat-tolerant variety is enabling farmers to grow wheat in an area where temperatures were too high and the season too short for growing traditional varieties.
- In Bangladesh, new lentil varieties combine high protein levels with micronutrients such as zinc and iron.
- A drought tolerant variety of chick pea introduced in Turkey had such strong resistance that it was able to withstand the searing temperatures and rainfall scarcity of the 2007 drought. The 'Gokce' variety is now used for about 80% of the country's chickpea production. With a yield advantage of 300 kg/ha over other varieties and world prices of over US\$1000/t, this variety brought in an additional US\$165 million for Turkish farmers in 2007 alone.

2.3 Diversification -- spreading the risk to earn higher revenues

Diversification of agricultural systems can be an effective means of mitigating risk and increasing income. In both high potential areas and marginal lands, this approach is proving an important strategy.

Herders in rangeland areas are being encouraged to produce value-added products such as yoghurt and cheese from their sheep and goats. Plans to develop crops with low water requirements are another option. In Tunisia, pastoralists are growing spineless cactus as fodder for their ruminants. The Awasi sheep, a hardy native breed brings resilience to rural communities in the Middle East. With good resistance to high temperatures and low rainfall, this is one of several indigenous breeds that have considerable potential for use across marginal lands in many dry land countries, providing meat, milk and wool for farmers.

2.4 Integrated crop-livestock systems

Crops or livestock. Why not both?

Farmers do not always have to choose between crop or livestock systems. New methods are needed to cope with a changing situation and integrating crop-livestock systems can be a highly effective way of cushioning each sector from external pressure and getting maximum effects from a symbiosis of both. Successful technologies that combine crop and livestock systems include:

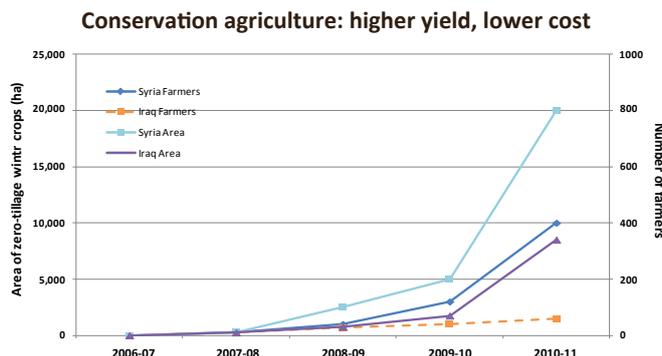
- On-farm feed production
- Rotation of barley with forage legumes
- Growing cactus and fodder shrubs
- Making feed blocks from crop residues and agro industrial by-products

2.5 Conservation agriculture produces more for less

Conservation agriculture (CA) – also known as zero till and no till -- is particularly well suited to dryland farming, especially in rainfed conditions. The technique involves avoiding tilling soil, conserving nutrients and water in the undisturbed soil, and retaining crop stubble. Crop rotation is an important part of the approach, which produces significant benefits through lower production costs, higher yields and better soil health and nutrient recycling. Under conservation agriculture soil carbon is retained and increased, contributing to climate change mitigation.

Field trials on wheat, barley, lentil and chickpea have produced documented evidence. By using conservation agriculture together with good crop management, farmers can increase net revenues by about US\$120 per hectare. The extra revenue comes from higher yields (12% increase) and lower production costs (saving of \$40 per hectare for each eliminated plowing).

In four years, adoption has grown from zero to almost 27,000 hectares in Iraq and Syria. To encourage mechanization, specially designed zero-tillage seeders have been developed. These are manufactured locally by small-scale entrepreneurs. They cost \$1,500 to \$5,000, compared with \$50,000 to \$60,000 for imported machines



Overview of farmer uptake of conservation agriculture practices in Syria and Iraq. Keys to adoption are farmers illustrating results to colleagues and availability of locally made (and locally repairable) seeders

Small-scale animal breeding produces big results

Community-based breeding programs are proving a valuable approach for small-scale livestock farmers in remote dryland areas. Focusing on indigenous breeds of mainly sheep and goats, this sustainable alternative to more modern breeding programs has already proved highly successful in Bolivia, Ethiopia, Mexico and Peru.

In Ethiopia, more than 500 households in remote communities have used the approach since 2008. They have been rewarded with improved flock genetic quality, animal health and productivity, and income from lamb sales.

Water productivity

Increasing yields at any price?

Dr. Theib Oweis, Director, Water and Land Management Program, ICARDA

Why must farmers manage with less water?

Food security is very closely associated with water security. Increasingly, agriculture's share of water is going to other sectors: industry, the environment and increasing urban growth. But at the same time, everyone wants more food.

So what are the options?

Most countries are relying on increasing the efficiency of irrigation systems to save water. My argument is that this will not solve the problem – they will not have enough water to increase productivity sufficiently to achieve food security. Part of the solution should come from increasing water productivity – the return for a cubic meter of water.

Could you explain this concept?

Currently, the strategy is to increase the return on cubic production unit of land. But our research shows that increasing yields requires more water. The same goes for expanding land area under cultivation. So this approach is not valid for water scarce areas facing climate change.

What do you propose in its place?

Instead of focusing on land and yield we should shift the focus to water productivity. The total return of m³ of water consumed. With less water, you can produce more food.

Can you give examples of some techniques?

Using deficit irrigation, you irrigate less than the full requirement. You may reduce the yield by 10%, but you will save 50% of water. You can use this water on other land.

With supplemental irrigation to rainfed crops in dry lands, you apply a little irrigation selectively, during shortages. That saves the crop and improves quality. This is especially important for climate change.

What other options are available to farmers?

Water harvesting can be very effective, concentrating water into, for example, small basins where you can grow crops. Farmers can also space crops in strips, leaving a fallow strip in between. The water flows into the planted area, with help from channelling if necessary. Contour infiltration ditches stop runoff and soil erosion. Interventions such as these will be very important under climate change, when rainfall will become more erratic and intense."

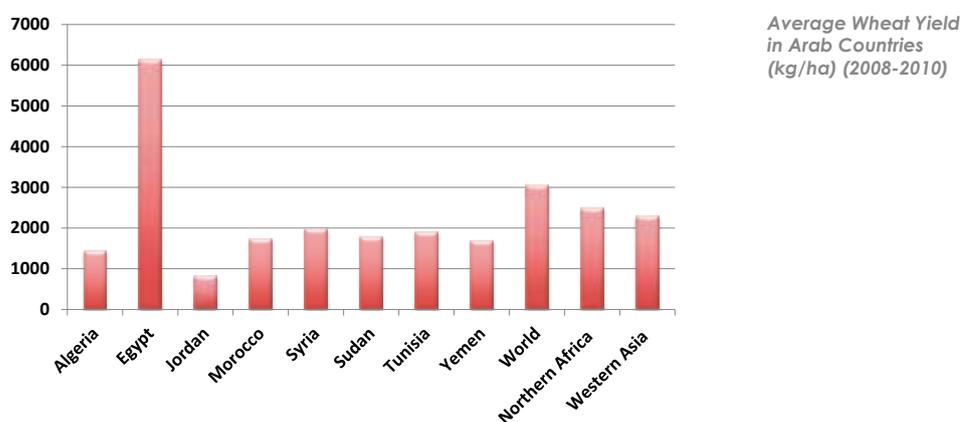
Conservation agriculture Bigger harvests for lower costs

To date, four out of the seven dryland countries involved in a project to increase wheat yields have taken up conservation agriculture (CA), with impressive results. CA has helped Jordan to increase wheat yields by 20%, while Syria has seen wheat yields rise by 17%. Morocco produced exceptional results in 2011, with a 50% rise in bread wheat yields, a 100% rise in durum wheat yields and a 50% rise in canola yields. Conservation agriculture produces even better results in drought conditions, since it allows the soil to retain the maximum amount of precious water and nutrients.

2.6 Getting innovations into farmers fields - examples of technology uptake in seven drylands countries.

A massive surge in wheat prices and availability in the wake of the 2007/8 global food price crisis prompted scientists at ICARDA and partner organizations to devise a strategy to help producers and consumers weather the shocks.

Arab countries have been hard hit by the soaring cost of wheat since all, except Syria, are net importers. Wheat yields in these countries are an average 30% lower than global levels, with the exception of Egypt.



Source: FAO, FAOSTAT- Agriculture

Focusing on wheat – a staple in the region – the project, launched in 2010/11, targeted six countries: Algeria, Egypt, Morocco, Sudan, Syria, and Tunisia. It was later extended to include Jordan.

The challenge of increasing wheat yields was not exclusively one of producing better technologies. It soon emerged that all countries had national research programmes with improved technologies, but most had yet to pass these on to farmers.

Dissemination of research results has therefore been a key component, using various methods to transfer technology, including mass dissemination, farmer field schools and lead farmers coaching satellite farmers. A total of 7,500 farmers were reached in the first 2 years. The scheme used a tried and tested model that encouraged farmers to explain why they did not adopt certain technologies. This was followed up by measures to address the issues.

The package varied, but could contain:

- Improved high producing varieties
- Adjusted methods, calendars and rates for planting
- Targeted fertilizer delivery, after soil analysis
- Improved water management
- Integrated pest management
- Conservation agriculture (no till)

Results included a 22% yield increase in Egypt and a 58% rise in Sudan, under real – not trial – conditions. The overall yield increase was 25%.

After the first year, there was already substantial spillover. In Egypt the model has been expanded, and the original 200 demonstration plots have become 1,300. The model has attracted considerable government support.

Morocco's Green Plan links smallholder farmers to lucrative export markets

In Morocco, where 71% of farms are under 0.5 ha, agriculture is at a crossroads. In an effort to drive the sector forward the government has drawn up an ambitious programme, which focuses on private and public investment, added value for fruit, vegetables and other sectors, as well as policy support for producer organizations, marketing and finance for farmers.

Dubbed the Green Plan, the initiative aims to have a significant impact on economic growth, as well as on land management, sustainable water development and employment, with a potential for creating a total 4 million new jobs.

The Green Plan is targeting new exports markets in Europe, the US, Russia and Asia, while also servicing the growing domestic market, particularly in rapidly developing urban centers.

With its fragmented land surface, where the average farm is only 2.1 ha, there is an urgent need to group producers together to increase their presence on markets and improve quality and processing.

The scheme involves sustainable intensification, diversification and development for marginal lands, cultivating olives, cactus and other suitable crops. The plan also includes measures to overhaul an industry framework that is out of step with principles of deregulation.

Adopting a market-based value chain approach has already brought success for the tomato sector in the Souss region, and the strawberry sector in the north. This latter has seen spectacular growth, exporting fresh but also frozen fruit for processing into products such as yoghurt, mainly to Europe. The model is now being duplicated using other soft fruit.

Producers in the dairy, sugar and sheep and goat sectors have all benefited by being grouped together and receiving help with modernizing production practices through transfer of skills and technology. The keystone to all these successes has been an entrepreneurial management approach by farmers, with encouragement and backing from the policy sector. Producers now have access to private investment and the plan is working to facilitate these channels, from national and international sources

Components of the strategy to modernize the industry framework include accelerating land privatization, giving incentives for a water pricing policy, improving access to wholesale markets and abattoirs and providing support for farmers, including access to credit and subsidies.

With its private, free trade approach and strong government backing, the Green Plan is widely seen as a policy model that could be adapted for other dryland countries.

The Green Plan has the potential to achieve greenhouse gas gains of 63.5 million tCO₂e over 20 years. These gains are expected largely from the sequestration of soil carbon through improved agronomic practices.

2.7 Better water management

The key to sustainable food production in dry lands

Water is the common denominator for problems affecting farmers in dry land countries. Depletion and mismanagement of groundwater reserves is being exacerbated by the effects of climate change, with less rainfall, and more erratic distribution. Population growth, pollution and increased salinity compound the problem, placing growing pressure on smallholder farmers in their quest for stable food production. The difficulties are becoming even more acute due to competing demands from rapidly increasing urban areas.

Dry areas have witnessed a steady decline in groundwater reserves in recent decades, mainly due to unregulated borehole drilling. Typically, water tables in semi-arid areas have dropped by between 0.5 and 2m per year, with serious impacts for both public supplies and ecosystems.

Farmers are the hardest hit, but they are also the biggest users of water. Globally, agriculture uses 70% of all water extracted from rivers, lakes and aquifers. In some low income countries, fresh water use for food production is as high as 90% or all available water resources.

However, while water issues are recognized by national leaders as a strategic priority, very few countries have a master plan for managing water in their agricultural sector and for dealing with the uncertainties that lie ahead.

It takes one liter of water to produce 1 kilocalorie of food. This means that each person consumes 3 to 4000 liters per day, just while eating. For that reason, it is crucial to invest in water efficiency for food security. Better water management, planning, technology and pricing mechanisms are some of the measures open to policy makers.

Using water wisely -- supplemental irrigation

Research and experience in the field show that supplemental irrigation, which allows farmers to plant and manage crops at the optimal time, regardless of climate vagaries, can significantly increase water productivity.

Here are some results from Ethiopia, Iran, Jordan, Lebanon, Pakistan, Morocco, Syria, Tunisia and Turkey.

On-farm water productivity is 2.5 kg/m³ under supplemental irrigation, compared with 0.3 to 1 kg/m³ under rainfed conditions and 0.75 kg/m³ under full irrigation.

Field trials in several countries showed massive increases in wheat and barley yields with small quantities of supplemental irrigation: yield increased from 1.25 t/ha to 3 t/ha in Syria, from 4.6 to 5.8 t/ha in Morocco, and from 2.2 to 3.4 t/ha in Iran.

Supplemental irrigation allows farmers to plant their crops early, increasing yields and preventing exposure to terminal heat and drought stress in hot areas and frost in cold areas.

How is water used?

As far as consumption is concerned, water use is embedded in different products. Beef has a much higher level of water use than beans on a per unit basis. In most Middle East and North African countries, a large share of water is imported as 'virtual water', in the form of imported grain. There is also an energy component, since virtual water, in the form of imported food, requires transport. Limiting imports, and expanding domestic food production through climate smart technologies, is a far more efficient means of using water and energy.

Challenges of water security must be addressed with sustainability in mind. It is important that even wealthy arid countries, that can afford costly desalinization schemes, pursue water resource management options that do not exact too high a cost either in financial terms, or social or environmental terms.

For poorer dry countries, what are the options?

Some solutions for water scarce dry lands

Irrigation efficiency, crop rotation and biotechnology – enhancing efficient water use in crops, are all options for making maximum use of scarce water reserves. Most of these approaches require advanced technology, such as using ground sensors to measure soil moisture.

Adapting crop varieties to use less water is a promising approach that is already producing impressive results in some dry countries. Investments in water technologies, such as drip irrigation, hydroponics, vertical agriculture and water harvesting techniques must go hand-in-hand with improved soil and crop management techniques. Conservation agriculture (zero tillage) retains precious moisture in soil that would otherwise be lost through plowing – also trapping nutrients and maintaining soil fertility.

Harvesting water in a dry lands context is markedly different from the conventional view of rainwater harvesting. In dry lands, new strategies are emerging for locating micro-catchments in areas where, apparently, there is no water. A combination of satellite remote sensing and observation on the ground can identify new water sources. Using this approach, countries can pinpoint where new sources exist and install appropriate structures to capture the water – for home use, animals or irrigation. This strategy has been tested in dry areas such as Jordan and Libya.

Involving rural communities

Rural communities may have more opportunities for developing water security than urban dwellers. Strategies open to them include careful conservation and management of renewable groundwater, rainfall harvesting and underground storage (in cisterns or aquifers). But the success of these initiatives will to some extent depend on improved weather forecasting, combined with education and training initiatives. It is important that farmers and other members of rural communities are involved from the outset in any changes in water use that will affect them.

Better tracking by government agencies will help to identify where water is being lost, in the environment and along the food production chain. A policy shift is also key, so that users have better incentives to adopt more sustainable water management practices. In dry land areas in particular, there is an urgent need for more data on groundwater reserves and water quality, and for improved monitoring strategies.

The resilience and adaptability of rural communities should be harnessed and developed. But there is also a need for more scientific know-how on water efficiency, especially for agriculture.

Sustainable water management options for the dry countries include:

- Modernizing irrigating systems and improving efficiency
- Modifying cropping patterns to enhance water productivity
- Supplemental (targeted) irrigation
- Macro and micro water catchments
- Watershed management
- Deficit irrigation.

Traditional systems for water harvesting and conservation

Water harvesting can be an effective, low-cost technology to conserve every last drop of available moisture. In the dry lands, there is scope for harnessing traditional knowledge developed over generations by rural communities. Examples include underground cisterns, flood harvesting systems and basins for collecting water and channelling it for household use and horticulture.

Many dryland countries, have a strong tradition of water storage. Building on these technologies, the resilience and adaptability of rural communities can be developed further.

Systems developed over generations in dry land areas include flood water spreading, plowing and terracing techniques, bunds, modified streambeds, cisterns, leaky dams and check dams.

- Qanats, an ancient Iranian water management system.
- In Rajasthan, India, small-scale water harvesting systems have succeeded in raising water tables and making dry rivers run again. These community-led schemes also have job creation potential and often provide one, two or three crops a year.
- In Sudan, the Hafir system involves flood spreading, storage and aquifer recharge, with a filtration component before water is distributed to local communities.
- Massive underground cisterns are used in Syria, to collect and conserve precious water.
- More recently, scientists have designed affordable water harvesting technologies for testing in several countries including Syria, Jordan and Libya – three of the world's driest regions. They combine the latest technology, such as GIS analysis to identify areas best suited for constructing water harvesting systems, with time honored techniques.
- In Eritrea, ICARDA and partners used a GIS model to map the Zoba Debub area in order to assess the different water harvesting techniques. Results showed that water harvesting potential was much higher than thought.
- In Jordan, a technology package (water harvesting plus other innovations) has helped rehabilitate degraded rangeland areas, reduce erosion, and improve the production of fodder for livestock.

Examples presented by Prof. Mike Edmunds, Oxford University.

Addressing Climate Change: Adaptation? Mitigation? Or both?

Interview: Dr Bruce Campbell, Director, CCAFS.

What is the priority for agriculture in the global climate change negotiations: adaptation or mitigation?

In the countries where we work, adaptation is the priority. If you look at the prognosis for Africa, you can see that climate change can potentially devastate agricultural production, through rising temperatures, more frequent and severe extremes, and increased aridity. But fortunately, for many of the options that are needed to build adaptive capacity, they also provide what we call a 'mitigation co-benefits'.

Can you give an example of a mitigation co-benefit?

A great example comes from Niger, for farmer-assisted tree regeneration. Farmers have added trees in the landscape over an area of five million hectares. This is essentially rehabilitating degraded farmland. Through this practice, crop yields have increased and there is more fodder for livestock. Some 2.5 million households have benefited.

This practice contributes to both climate change adaptation and mitigation. The enhanced and more diverse livelihood portfolios that families in this area have – different production and income streams – allow them to cope better with current and future climate-induced risks. These approaches also bring large-scale sequestration of atmospheric carbon created by the 200 million new trees and also reduced carbon loss from soils - reducing loss of topsoil through wind and water erosion.

Is this achievement the result of agricultural or climate change research or a development project?

Partly. This grew out of a traditional woodland management approach, pioneered by farmers in Niger over many years, and. It involves selecting, protecting and pruning re-growth from living tree rootstock. It became known as 'Farmer Managed Natural Regeneration' (FMNR). Research has helped better understand this and to identify opportunities for scaling-up in other locations. A new feature furthered by intermediary organizations that assisted the farmers was to incorporate FMNR into agricultural crop lands so that trees are managed as part of a farm enterprise. In the 1980s FMNR became a component of a development project and by 1985, 500,000 trees in 95 villages had been regenerated and protected.

3. Climate change interventions

Changing climate patterns will affect people in all ecosystems. But those living in dry areas will face more acute challenges. Countries already suffering from high poverty levels due to poor land and water availability are being hard hit by climate change, with erratic rainfall, more frequent droughts, extreme temperatures, shifting climatic zones and the arrival of new crop pests and diseases.

3.1 New problems need new solutions.

Approaches to help buffer the effects of climate change on farmers range from simple solutions to high-tech options, and from insurance mechanisms to safety nets for vulnerable communities. Climate smart technologies can raise agricultural productivity, reduce rural communities' vulnerability to weather extremes and cushion people from the impacts of food price volatility. This approach holds out special hope for dry lands.

When carefully managed, climate smart initiatives can produce tangible benefits to rural communities and the land they depend on, making it more resilient when faced with climate swings. Promising technologies to combat this unpredictable situation include crop varieties adapted to perform well under climate change factors, technology tools, devices for farmers and systems for delivering targeted timing and doses of fertilizer and irrigation.

Lesson from Niger's farming communities – farming trees for income and land regeneration

'Farmer-managed natural regeneration' (FMNR) is a simple, low-cost practice pioneered by farmers in Southern Niger and encouraged by development projects to become a component of farming practices.

It encourages natural tree re-growth by selecting, pruning and protecting naturally regenerating trees, and uses living rootstock it makes tree planting easier. This approach has potential for the regeneration of degraded lands.

- The method is flexible, adapting to farmers' situations and needs.
- FMNR increases the farmers' supply of a range of products that farming households can either consume or sell - fuel, food, medicine and fodder, and specifically benefits women.
- Research has shown that adopting FMNR increases access to market and levels of farmer education. The approach is also associated with increased household income, crop and tree diversity and lower migration rates, but in the survey area did not result in increased crop yields.
- Advocacy for a change in policy were important to the spread of the FMNR practice in the region. Uptake was further stimulated after the Nigerien Government eased restrictive national forestry regulations in the 1990s and again in 2004. This allowed the farmers 'rights' to the trees that they protected – that had previously belonged to the Government.

Summarized from paper on Farmer Managed Natural Regeneration in Niger - Sidsel F. Cappiello and Peter Cooper (see reading list).

3.2 Climate smart options

Climate smart technologies currently being developed and trialed by CGIAR research centers and other organizations include work on shade agriculture, soil carbon sequestration, early warning systems, livestock insurance schemes, rotational grazing and flexible water storage options. Research shows it is important that techniques are tailored to local conditions and backed up by policy, technical and financial support.

As well as measures taken at farm level, such as the introduction of climate adapted crops, it will be important to make adjustments at institutional and policy level, promoting systems that can protect livelihoods and the environment. These may include changing the way that agricultural extension is delivered, how weather forecasts are given or through new safety nets, such as insurance for farmers and cash transfers in times of need.

3.3 Capturing carbon

Increased carbon sequestration – for example by planting trees -- can make an important contribution to mitigating climate change, and dry areas have significant potential here. It has been calculated (Lal 2000) that drylands can sequester 0.9-1.9 Gt C per year. This compares with tropical deforestation releasing 0.6-0.9 Gt C per year. However, to achieve even a fraction of this potential requires a co-ordinated effort at national and international levels. Landscape restoration can have both adaptation and mitigation benefits.

Carbon and climate change mitigation funds benefit farmers

Climate funds for reducing greenhouse gas emissions can benefit small farmers and help achieve development objectives, according to a report from the CGIAR Research Program on Climate Change Agriculture and Food Security (CCAFS) and partners.

In a study of six African agricultural carbon projects, researchers found that communities are benefiting from a range of activities related to planting and managing trees on farms. The carbon projects include the Humbo Ethiopia Assisted Natural Regeneration Project, which was the first African forestry project to be registered under the Kyoto Protocol, and the Cocoa Carbon Initiative in Ghana, which is working to improve tree cover while enhancing sustainability of cocoa production.

The study found that while direct carbon payments to farmers were low, projects established systems for financial management, agricultural extension, and carbon monitoring involving a complex set of partnerships. The study demonstrates the different channels through which communities could benefit from mitigation funds for agricultural development.

3.4 Climate initiatives

Some of the most effective climate initiatives launched to help rural communities weather shocks caused by climate change include:

- **Ethiopia's Productive Safety Net Program (PSNP).** Launched as an alternative approach to food aid, this program reaches some 7 million people. It includes a public works component that involves landscape and watershed rehabilitation, at the same time providing jobs for rural communities and increasing food security.
- **Weather-based insurance schemes** can offer valuable protection to farmers faced with erratic climate conditions. Such initiatives encourage producers to continue investing in farming, safe in the knowledge that they will be protected if natural events prevent them from reaping the profits they deserve. In Kenya, a livestock insurance system has started paying out dividends to herders who have lost animals to drought, and is now being rolled out to other dry areas.

There is also interest in linking micro insurance initiatives such as this to microfinance schemes, providing a one-stop affordable finance package for smallholder farmers. India's Weather-based Crop Insurance Scheme (WBCIS) covered over 9 million farmers in the 2010-11 agricultural year. The policies covered more than 40 different crops and 9.5 million hectares. The volume of paid claims in 2011 amounted to US\$125 million.

- **Climate information services** can be valuable tools, especially if adapted to local farmers' needs. One example is a 5-day forecast sent via SMS on mobile phones, with advice given to farmers on what they should be doing, based on the weather.
- In Niger, **the planting of 200 million nitrogen-fixing trees** such as *Acacia senegal* and *Acacia seyal* has resulted in the transformation of five million hectares of once infertile land. The initiative has increased crop yields and fodder availability, benefiting 2.5 million farmers. Trees increase the carbon stored in the landscape, mitigating climate change. Each farmer involved in the initiative has benefited by an annual average of US\$56 per hectare. There are prospects of higher revenues if carbon credits are introduced. Trees increase the carbon stored in the landscape and more diverse and sustainable livelihoods increase adaptive capacity
- Groups of lead farmers in Tunisia are being linked by mobile phone to crop and weather monitoring systems that issue alerts when irrigation is needed. The information can then be relayed to other producers. Public and private funding will be key to the rapid implementation of climate smart agriculture in drylands. More attention must be devoted to quantifying benefits from climate-smart agriculture, providing the evidence for scaling up.

4. Agricultural research

Strengthening agricultural innovation systems through research, education and extension

4.1 Technical solutions

Agricultural research offers practical solutions to many of the constraints posed by climate change. A range of practical techniques can be highly effective, especially if supported by an enabling policy environment. In Egypt, for example, sowing wheat on raised beds increased yields by 25% in one season. Planting early varieties of rice, that can be harvested 20-30 days earlier, can make significant savings in water consumption. Experience is showing that an integrated 'agro-ecosystems' approach is required - to apply technical options in a 'holistic' way, to deliver real benefits to people's livelihoods.

4.2 Policy

The right environment

An enabling national policy environment is essential to support investment in agricultural development, drive sustainable productivity growth and encourage better farming practices, including natural resource management. In many dryland countries, there is a strong need for more capacity development and institutional support. Agriculture, which is the backbone of most dry land economies, needs to be a national priority. This is especially important given the inexorable onset of climate change. Real advances can be made in adapting to its impact, but only if there is the right backing in terms of science, technology and research, so that farmers have real help in adjusting to new conditions. In the UNFCCC the technology transfer mechanisms and the work around capacity building can, if agriculture receives deserved attention, help in getting technologies to farmers and building capacity around climate smart agriculture.

4.3 National and regional

While the United Nations Framework Convention on Climate Change (UNFCCC) will cover the international policy framework for how agriculture is incorporated into future climate agreements, developing regional and national policy is an urgent priority. Farmers need policies that support the introduction of climate smart farming techniques. Policies and strategies should recognize proven technologies for carbon sequestration, such as mulching, intercropping and agroforestry. Experts have also called for more backing for climate risk management, including insurance and productive safety nets and better access to weather information adapted to farmers' needs.

4.4 Extension

Pass it on

Often, a major challenge is in getting results of agricultural research off the shelves and out into the fields. Many scientists themselves now recognize the need for closer links between researchers and farmers and the fundamental role played by innovative extension approaches.

Effective technology transfer mechanisms are essential, not just between researchers and farmers, but between farmers and other farmers. The best models target farmer feedback, with follow up to find out what works best, what does not work, and why.

Rewarding successful farmers with certificates or small gifts can be an effective way of raising awareness of better practices and generating support in the rural community.

4.5 Investment

Good returns

Agriculture continues to be the main engine for economic growth in most dry land countries, and experience has shown investment in research generally produces excellent returns – often better than those of the commercial sector. Yet spending remains low in many dryland countries. In general terms, agricultural research is not a high investment priority for governments of developing countries. Many dryland countries spend between 0.2% and 0.5% of agricultural GDP on research. Decisions to save money by failing to invest in technology to make food production more efficient could cost countries very dearly in the long run.

Countries that have made investments in science and technology and agricultural research have seen impressive national growth as a result. Cases in point include Brazil, China and India, and, more locally, Tunisia and Morocco. The repercussions of investment in agricultural research go way beyond the immediate farm sector, with a ripple effect that takes in transport, agro industries and the social dimension, helping to create jobs, livelihoods and stability, so people can realize their full potential.

More funds are needed to promote adaptation. Potential sources include national budgets, donors and development agencies and more innovative sources, including the private sector and carbon markets. It will be important to develop a policy framework for public-private partnerships that can attract responsible private investment in the agriculture sector, and dry lands in particular.

Research pays dividends.

In Ethiopia, where the government has made agricultural research a priority for much of the past decade, lentil production tripled between 2000 and 2010, using the same amount of land and smaller amounts of fertilizer. Over the same period, faba production increased by (broadbean) 40% and chick pea production rose by 30%. In 2010, the country exported more pulses than coffee.

4.6 Working together

Partnerships are an important mechanism for sharing knowledge and solutions. Options for alliances that can help dryland countries improve agricultural performance and adapt to climate change challenges include those between:

- National agricultural research systems
- International centers
- Global and regional fora

4.7 North-South, South-South

Wealthy arid countries may have important lessons to share with poorer ones. Australia, the driest continent on the planet, is helping dryland areas in the Middle East and North Africa with technology adaptation and transfer. The initiatives, supported by ICARDA, have all produced very high returns on investment. They include:

- Conservation agriculture in northern Iraq
- Yield gaps in Egyptian irrigated farming systems
- Conservation agriculture in Tunisia

In 2012 CCAFS supported South-South exchange between India and countries in West Africa on climate information services. Thus South-South cooperation is also key. Agreements between countries facing similar problems are needed to capitalize on existing financial and technical experience and expertise, including the development of partnerships at sub-regional, regional and international levels.

Reading List

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

<http://ccafs.cgiar.org/>

CCAFS Report 8: *Institutional innovations in African smallholder carbon projects* (PDF) by Seth Shames, Eva Wollenberg, Louise E. Buck, Patti Kristjanson, Moses Masiga and Byamukama Biryahwaho

CGIAR Research Program on Dryland Systems

www.icarda.org/dryland_systems

Food Security in Dry Lands Conference

www.fsdl.qa

Ministerial Dialogue: Policy Brief - Opportunities for Food Security

Downloadable from

<http://www.fsdl.qa/en-us/program/ministerialdialogue/policybrief.aspx>

International Center for Agricultural Research in the Dry Areas (ICARDA)

<http://icarda.org/>

UNESCO regional water centers

<http://www.unesco.org/new/en/natural-sciences/environment/water/ihp/water-centres/>

Unesco Global Water and Development Network for Arid Lands

www.gwadi.org

School of Geography and the Environment, University of Oxford.

www.water.ox.ac.uk

Rainwater Harvesting for Agriculture in the Dry Areas

Theib Y. Oweis, Dieter Prinz & Ahmed Y. Hachum

Garrity, D.P., F.K. Akinnifesi, O.C. Ajayi, S.G. Weldesemayat, J.G Mowo, A. Kalingarine, M. Iarwanou and J. Balaya (2010). Evergreen Agriculture: a robust approach to sustainable food security in Africa. *Food Security*. 2:197-214.

Haglund, E., Ndjeunga, J., Snook, L., Pasternak, D. (2011). Dry land tree management for improved household livelihoods: Farmer managed natural regeneration in Niger. *Journal of Environmental Management*. Vol 92 p. 1696-1705

Reij C., Tappan G., Smale M., (2009). Agroenvironmental Transformation in the Sahel – Another Kind of “Green Revolution”. IFPRI Discussion Paper 00914

Reij C., Tappan G., Smale M., Agroenvironmental Transformation in the Sahel – Another Kind of “Green Revolution”. (2010). In: *Proven Successes in Agricultural Development*

A Technical Compendium to Millions Fed. Edited by David J. Spielman and Rajul Pandya-Lorch

Rinaudo, T. (2008). The Development of Farmer Managed Natural Regeneration

Tougiani A, Guero C, Rinaudo T (2009). Community mobilisation for improved livelihoods through tree crop management in Niger. *GeoJournal* 74:377–389

UNDP, UNEP, World Bank, World Resources Institute (2008). *World Resources 2008: Roots of Resilience e Growing the Wealth of the Poor*. July. Available from:

<http://www.wri.org/publication/world-resources-2008-roots-of-resilience>

Annexes

Annex 1

DOHA DECLARATION ON FOOD SECURITY
International Conference on Food Security in Dry Lands
Doha, Qatar
14-15 November 2012

We, the Ministers and representatives of countries, together with the scientific community and international development partners present at the International Conference on Food Security in Dry Lands, held in Doha, Qatar on 14-15 November 2012:

Reaffirming the commitments of our countries to the goals of sustainable development and the millennium development goals, especially those pertaining to fighting poverty and promoting food and nutritional security;

Recalling the commitments of the African and Arab Ministers and Head of States, contained in the 6th World Water Forum Declaration of Marseille The Time for Solutions (2012), the 2nd Arab Water Forum Cairo Declaration on Living with Water Scarcity (2011), the Johannesburg Communiqué on Climate-smart Agriculture (2011), the Sharm El Sheikh Declaration on Agriculture Development and Food Security in Africa and the Arab Region (2010), the Abu Dhabi Declaration on Food Security for Gulf Cooperation Council Countries (2010), the Kuwait Declaration at the Arab Economic, Development and Social Summit (2009), the Declaration of the World Summit on Food Security (2009), the Sirte Declaration on Water for Agriculture and Energy in Africa (2008), the Riyadh Declaration on Enhancing Arab Cooperation to Face World Food Crises (2008), the Maputo Declaration on Agriculture and Food Security in Africa (2003), the Committee of Food Security and the decisions of the Organization of the Islamic Conference on food security and agricultural development;

Concerned that over 40 percent of the world is dry lands, where about 2.3 billion people - one third of the global population - live in nearly 100 countries and that in recent decades, the production of food and other goods and services have fallen drastically in most dry lands;

Recognizing the crucial roles and responsibilities of women in subsistence and commercial crop and livestock production in dry land countries and their contributions to helping meet food security at household, local and national levels;

Recognizing that, characterized by water scarcity, the dry lands have less than eight percent of the world's renewable water resources and are challenged by extremes of temperature, frequent drought, land degradation and desertification. Poverty is disproportionately concentrated in dry lands; population growth is high; and women, children and pastoralists are highly vulnerable;

Recalling vulnerability of the food production systems in dry lands and the risks to food and nutritional security aggravated by international food prices fluctuations as well as adverse climatic events;

Underscoring that food security, poverty and climate change are closely linked and should not be considered separately;

Noting that without strong adaptation measures, and financing to support them, poverty alleviation and food security goals will not be attained;

Recalling that adaptation measures not only enhance food security but can potentially contribute to reducing greenhouse gas emissions from agriculture;

Recognizing that water and desertification are the most limiting factors to foster economic, social, and environmental development in dry lands and that the sustainable utilization of water resources is a priority at regional and national scales;

Stressing the need for the wise utilization of the available water in dry lands without compromising the ecological rights of the ecosystem components to ensure continuous gains of the ecosystem services;

Recalling the targets recommended in the WWF6 held in Marseille in March 2012 for increasing water use efficiency by 2020 for improving irrigation efficiency;

Recognizing the further efforts needed to develop an enabling policy environment and infrastructure to promote responsible investments in land and water resources for agriculture, in the spirit of regional and international cooperation and agreeing on the principles of the "Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security";

Recognizing the key contributions made by farmers, co-operatives and by other agents in private sector food supply chain markets to global and local sustainable food and water security;

Recognizing that knowledge, data, processes and decision support tools for dry land systems need improvements;

on on-going programmes supportive to agriculture and food security in dry lands, including the Strategy for Sustainable Arab Agricultural Development until the year 2025; the Strategy for Water Security in the Arab Region for the year 2010-2030 endorsed by the League of Arab States (LAS) in 2012; ICARDA's Strategy, 2007-2016: Improved Livelihoods in Dry Areas; the Comprehensive Africa Agriculture Development Program (CAADP); and TerrAfrica Partnership on Sustainable Land and Water Management

We, the ministers and representatives of countries, commit ourselves to:
Cooperation at the International/Regional Level

Support the United Nations Secretariat and specialised agencies in the efforts of enhancing food security;

Adopt sound agricultural and rural development plans at international, regional and national levels, including national and trans-boundary priorities for water, land and agricultural development;

Promote South-South cooperation agreements to capitalise on existing financial, technical and institutional expertise and experience, including the development of effective partnerships at sub-regional, regional and international levels;

Encourage bilateral and regional agreements on shared bodies of water and strengthen existing river basin organizations to promote regional cooperation, sustainable water resources development and management in accordance with international law and agreements to reduce the risk of conflict;

Foster the harmonization of legal standards of land tenure governance, in accordance with existing obligations under national and international law and strengthen existing international measures to administer tenure rights that cross international boundaries;

Welcome and support the launch of the CGIAR Dryland Systems Program, led by ICARDA, given its relevant, innovative and integrated system approach to enhance the sustainable intensification of production systems and to increase systems and livelihoods resilience in dry lands;

Welcome and support Qatar's initiative to establish a Global Dry Land Alliance (GDLA), a collaborative undertaking to create new solutions to common food security problems and to provide mutual assistance in times of extraordinary need;

Financing and Investment

Call for the commitment of national governments, donors, development organizations, and national, regional and international research institutions to give agriculture, in general, and dry lands, in particular, higher priority in the annual budgets and financing plans;

Mobilize additional funds to promote adaptation and disaster risk reduction within the agricultural sector from national budgetary resources and available climate funds, including carbon markets;

Enhance access to rural financial services to smallholder farmers, women and youth who are essential for sustainable farming in the dry lands;

Call upon the Islamic Development Bank, the African Development Bank, the World Bank, IFAD and regional financial institutions to: (i) strengthen countries' capacities in project development and investment prioritization in order to effectively accelerate investments in agriculture and food security; and (ii) scale-up landscape approaches which aim to reduce poverty, build resilience, increase food security, mitigate greenhouse gas emissions and promote sustainable agricultural intensification;

Highlight for investors the potential of sustainably intensifying rainfed and dryland farming and the dangers of developing unsustainable use of surface and ground water resources;

Promote innovative financing and innovative financing solutions for agriculture, food security and nutrition;

Call on further investments to design effective safety net programmes, including crop insurance, in order to address risks, vulnerability and help vulnerable small farmer households be protected against livelihoods risks and maintain an adequate level of food security;

Promote inward investment projects in water and land that produce food for local markets and work on the development of value chains;

Promote the development of international partnerships, involving countries investing abroad and recipients of investments: (i) to monitor and coordinate cross-regional investments in land and water resources and, (ii) to facilitate the conclusion of responsible investments that safeguard original tenure rights, livelihood of the population affected by the investment projects, natural resources and equitable sharing of benefits;

Research and Development

Increase investments in research and development, optimize the use of scarce water resources, scale-up sustainable land and water management approaches and promote the sustainable use of common biological, water and land resources, particularly rangelands;

Ensure the long term conservation and utilization of biodiversity, including crop wild relatives and landraces, before it is lost;

Revitalize, systematize, and scale-up existing local and traditional and improved knowledge, including heritage systems and ecosystem services that can effectively support adaptation to climate change by rural communities and strengthen the deployment of adequate new technologies;

Promote, with the support of UNESCO, FAO, ICARDA with the CGIAR and other specialised agencies, the establishment of inter-disciplinary regional centres of excellence and networks for food and water security, climate change, clean energy, water and land management, desertification, and environmental conservation in dry lands;

Ensure that development investments in the dry lands are designed around triple-win solutions: (i) increasing farm productivity and income; (ii) making smallholders more competitive and resilient to climate variations to reduce their vulnerability and food insecurity; (iii) helping to limit the ecological footprint of agriculture;

Promote the adoption of policy, legal and organizational frameworks in dry lands, with inputs from the civil society and the support of research and academic institutes, that promote responsible investments in foreign land and water resources in line with the "Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security", in the respect of international law and of the needs and rights of the local population;

Promote water and food security partnership networks to harmonize, at regional levels, efforts to enhance food security, coordinate investment in agriculture, develop decision support tools for adaptation at national and regional levels, facilitate the exchange of information on the status of food reserves, promote the adoption of water-saving technologies and appropriate land conservation practices, and organize farmers' capacity building programmes;

Climate Change and Food Security

Call on developed countries and other partners to support the implementation and scaling up of early action programmes, including best practice and technologies in climate-smart agriculture and food security through regional, sub-regional and national programmes and institutions as a matter of priority;

Promote early action to improve the viability, scope and accessibility of agricultural options for climate change adaptation and mitigation;

Call upon the parties to COP18/CMP8 in Doha to decide to establish a SBSTA agenda for agriculture, particularly in dry lands;

In order to accomplish these goals, we commit to Promote sound policies for agricultural and rural development, and call upon respective governments for the allocation of 10 percent of national budgetary resources for the implementation of this declaration;

Support Qatar's initiative at national, regional and international levels to establish a Global Dry Land Alliance (GDLA) and explore possible dedicated financial mechanisms;

Establish a permanent secretariat for the FSDL under the Qatar National Food Security Programme to promote the implementation of this declaration and to support and enhance food security in dry lands, in partnership with governments, multilateral organizations, business, research and academic institutions;

Create a mechanism using reliable indicators to monitor and evaluate the implementation of this declaration, in close collaboration with FAO and AWC;

Establish, with the support of national and international organizations, an information system in the field of agricultural production for food security and the trading of commodities between markets and countries in dry lands;

Establish and enhance Early Warning Systems at national and regional levels to minimize the negative impacts of droughts, floods, desertification, and pests.

CONFERENCE AGENDA



14 November			
09.00 - 10.15	Opening Session (IBN KHALDOON)		
10.45 - 11.15	Plenary Roundtable Discussion		
11.30 - 13.00	Causes and Consequences of Food Insecurity in the Middle East Organizer: CIRS – Georgetown University	Water, Ecosystems, Salinity and Management Solutions Organizer: UNESCO	Investment Envelope for Land and Water in the Arab Countries: Current State and Trends Organizer: FAO
Venue:	IBN KHALDOON	LIBRARY AUDITORIUM	LIBRARY EXHIBITION AREA
14.30 - 16.00	Food Security: Beyond food production Organizer: The World Bank	Strategic Water Management Solutions in Dry Lands Organizer: UNESCO	Extra-Territorial Investment in Land and Water: Closing the Investment Gap in a Responsible Manner Organizer: FAO
Venue:	IBN KHALDOON	LIBRARY AUDITORIUM	LIBRARY EXHIBITION AREA
16.30 - 18.00	Role of Science and Technology in Enhancing Food Security in Dry Areas Organizers: ICARDA and IFAD	Water Management: Challenges and Opportunities Organizer: AWC	Responsible and Sustainable Investment in Land and Water Resources Organizers: QEERI and KCL
Venue:	LIBRARY AUDITORIUM	LIBRARY EXHIBITION AREA	IBN KHALDOON

15 November			
9.00 - 10.30	Prospects for Enhancing Food Security in Dry Areas Organizer: ICARDA and IFAD	Water Management: Strategies and Action Plans Organizer: AWC	Responsible and Sustainable Investment in Land and Water Resources Organizer: QEERI and KCL
Venue:	LIBRARY AUDITORIUM	LIBRARY EXHIBITION AREA	IBN KHALDOON
11.00 - 13.00	Ministerial Dialogue – The Energy – Water – Food Nexus (IBN KHALDOON)		
14.30 - 16.30	Ministerial Dialogue – Financing dry land agriculture and food production (IBN KHALDOON)		
17.00 - 18.00	Closing Ceremony (IBN KHALDOON)		


www.fsd1.qa

Annex 3

Speakers and Authors at the International Conference on Food Security in Dry Lands Doha, Qatar, November 15, 15 2012

Prof. Dr. Ir. Bart Schultz
Emeritus Professor of Land and Water Development, UNESCO-IHE, Delft, the
Netherlands Dr. Rachael

McDonnell
Water Policy and Governance Scientist, ICBA
Dr. Theib Y. Oweis
Director of the Integrated Water and Land Management Program of ICARDA

Prof. Jad Chabban
Assistant Dean, American University of Beirut

Prof. Jane Harrigan
Professor, University of London

Prof. Martha Mundy
Professor, London School of Economics

Prof. Ray Bush
Professor at the University of Leeds

Dr. Anil Mishra
Programme Specialist, UNESCO

Prof. Mike Edmunds
Professor, University of Oxford

Prof. Waleed K Al-Zubari
Professor, Arabian Gulf University

Dr. Maurice Saade
Senior Agriculture Economist, The World Bank

Dr. Rabi Mohtar
Executive Director of Qatar Energy and Environment Research Institute (QEERI)

Dr Mahmoud Solh
Director General
ICARDA

Dr. Kamil H. Shideed
Assistant Director General for International Cooperation and Communications,
ICARDA

Dr. Tony Allan
Head of the London Water Research Group, King's College London and SOAS

Dr. Turki Faisal Al Rasheed
Chairman of Golden Grass, Inc. (GGI)

Dr. Madiodio Niassé
Director, International Land Coalition

Dr. Lowenberg-DeBoer
Associate Dean and Director of International Programs in Agriculture (IPIA), Purdue
University

Dr. Timothy O. Williams
Director for Africa at the International Water Management Institute (IWMI)

Dr. Eckart Woertz
Senior Researcher, Barcelona Centre for International Affairs (CIDOB)

Dr. Mark Mulligan
Reader in Physical Geography at King's College London.

Dr. Brian Chatterton
Former Minister of Agriculture, Fisheries and Forests - the Commonwealth of Australia

Dr. Lynne Chatterton
Political Science and History, Adelaide University

Dr. Maria Cristina Rulli
Assistant Professor, Polytechnic of Milan

Dr. Clemens Breisinger
Research Fellow, IFPRI

Dr. Yaya Olaniran

Dr. Thomas Rosswall
Chair, CIAT-CCAFS

Mr. Martin Keulertz
PhD Researcher at King's College London

Mr. Dominic Waughray
Senior Director and Head of Environment and Sustainability Initiatives for the World Economic Forum

Dr. Mahmoud Abu-Zeid
Former Minister of Water Resources & Irrigation of Egypt (12 years, 1997-2009).

Rami Abu Salman
Climate and Environment Advisor at IFAD

Dr. Pasquale Steduto

H.E. Dr. Hussein I. El-Atfy
Former Minister of Water Resources and Irrigation of Egypt (2011)

David B Roberts,
Deputy Director, Qatar office of the Royal United Services Institute for Security and Defence Studies (RUSI)

