IRMA

Third Stakeholders Meeting

Insect Resistant Maize for Africa (IRMA) Project

S. Mugo, D. Poland, M. Mulaa, and D. Hoisington - Editors

Hilton Hotel, Nairobi, Kenya
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International Maize and Wheat Improvement Center

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The Kenya Agricultural Research Institute (KARI) was established in 1979 with the express mission of increasing sustainable agricultural production by generating appropriate technologies through research, and disseminating these to the farming community. Inherent to this mission is the protection, conservation, and improvement of the basic resources, both natural and human. Such resources are critical for Kenya's agricultural development and expansion of the nation's scientific and technological capacity. KARI has an extensive history of productive collaborators with national and international institutes and universities, as well as with the private sector.

The Syngenta Foundation for Sustainable Agriculture provides major funding for the project. The Foundation is dedicated to fostering sustainable development in poor countries of the South through its support of programs and projects in the areas of sustainable agriculture, health, and social development. It is also an active player in development policy debate through its preparation and dissemination of research analysis. Further information about the Foundation may be found at its web site (www.syngentafoundation.com).

The International Maize and Wheat Improvement Center (CIMMYT)® (www.cimmyt.cgiar.org) is an internationally funded, nonprofit scientific research and training organization. Headquartered in Mexico, the Center works with agricultural research institutions worldwide to improve the productivity, profitability, and sustainability of maize and wheat systems for poor farmers in developing countries. It is one of 16 similar centers supported by the Consultative Group on International Agricultural Research (CGIAR, www.cgiar.org). The CGIAR comprises about 60 partner countries, international and regional organizations, and private foundations. It is co-sponsored by the Food and Agriculture Organization (FAO) of the United Nations, the International Bank for Reconstruction and Development (World Bank), the United Nations Development Program (UNDP), and the United Nations Environment Program (UNEP). Financial support for CIMMYT's research agenda also comes from many other sources, including foundations, development banks, and public and private agencies.

CIMMYT supports Future Harvest® a public awareness campaign that builds understanding about the importance of agricultural issues and international agricultural research. Future Harvest links respected research institutions, influential public figures, and leading agricultural scientists to underscore the wider social benefits of improved agriculture—peace, prosperity, environmental renewal, health, and the alleviation of human suffering (www.futureharvest.org).

The Insect Resistant Maize for Africa (IRMA) Project is a collaborative effort between CIMMYT and KARI, with funding and other support from the Syngenta Foundation for Sustainable Agriculture. Its primary goal is to increase maize production and food security for African farmers through the development and deployment of maize that offers resistance to destructive insects, especially stem borers. To achieve this goal, project scientists are identifying conventional and novel sources of resistance to stem borers and incorporating them into maize varieties that are both well adapted to Kenya's various agroecological zones and well-accepted by its farmers and consumers. Varieties and technologies that are appropriate for other African nations may be extended to them for their use.

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Executive Summary

The Insect Resistant Maize for Africa (IRMA) project is aims to produce stem borer resistant and locally-adapted maize for various Kenyan agroecological zones, using conventional and biotechnology-mediated methods, especially Bt technology. Transgenic maize containing *Bacillus thuringenesis* (Bt) is a focal point of the project, prompting project organizers to emphasize public involvement and awareness through events such as the Stakeholders Meeting.

The IRMA project was publicly launched on March 3, 2000 with the convening of the first Stakeholders' Meeting in Nairobi, Kenya. That meeting was attended by about 100 people, representing different stakeholder groups, including farmers' associations, women's groups, religious organizations, seed producers, regulatory agencies, NGOs, the media, and others. Representatives of the project collaborators, CIMMYT and the Kenyan Agricultural Research Institute (KARI), as well as the primary donor, the Syngenta Foundation for Sustainable Agriculture (at that time, the Novartis Foundation for Sustainable Development) were also on hand.

The specific objectives of the first stakeholders' meeting were to (1) introduce the IRMA project to stakeholders; (2) create awareness about the economic importance of stem borers in Kenyan agriculture; (3) create awareness about the control options for stem borers, including conventional and novel approaches like the Bt technology; and (4) solicit responses from stakeholders on the need for and processes of developing insect resistant maize for Kenya. The stakeholders expressed their desire that the project incorporate sound management strategies and that it follow the national regulations strictly during introduction and testing of Bt maize technology in the country. The near universal view was that we could only evaluate Bt maize technology if it is in the country. Bt maize was viewed as having high potential for closing the wide and increasing food deficit in Kenya.

The Second IRMA Stakeholders' Meeting was held on November 26, 2001 in Nairobi Kenya. Objectives in addition to those of the first stakeholders meeting were to (1) inform the stakeholders about the project's progress and (2) solicit feedback from stakeholders to help guide project scientists on the way forward.

At the second stakeholders meeting, participants expressed satisfaction with the progress of the project and suggested an increased emphasis on training. The stakeholders reiterated that Bt maize has high potential for closing Kenya's food deficit, and that Bt mazie genes can only be effectively evaluated if they are in the country. The farmer groups in particular indicated an eagerness to acquire the technology soon. They were informed that efforts were underway to test it under greenhouse and open quarantine field conditions, but that following the regulatory procedures and reviews was a necessary but time consuming part of the process. The stakeholders and the media were invited to see ongoing experiments and their results at all stages of development.

Media coverage in Kenya of the first and second stakeholders' meetings and the IRMA project has been maintained and has been generally positive.

The Third IRMA Stakeholders' Meeting was held on November 22, 2002 in Nairobi Kenya. The objectives remained the same as for the second meeting. The meeting attracted 86 participants, representing 42 institutions from within and outside of Kenya (see list of participants), and were from both the public and private sectors (Figure 1)

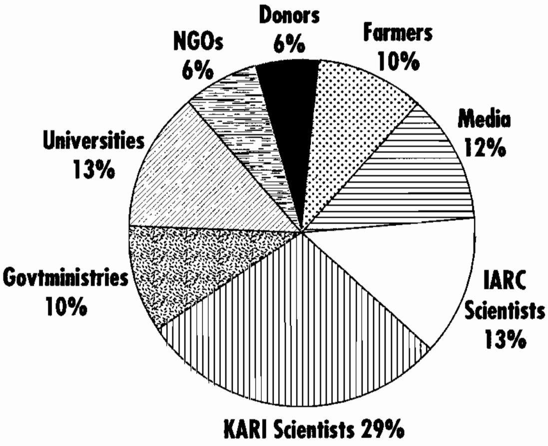

Fig. 1. Percent of participants (by categories of institutions) attending Third IRMA Project Stakeholders Meeting in Nairobi, Kenya, Nov. 22, 2002.

Dr. John Kedera, Director KEPHIS, chaired the Third IRMA Stakeholders Meeting. Dr. Joseph Ochieng, Assistant Director, KARI–Food Crops welcomed the participants on behalf of Dr. Romano Kiome, Director-KARI. Dr. Ochieng indicated the pride KARI attaches to the IRMA project as it promises to "transform" the economy of the Kenyan farmers by increasing food production and security by reducing yield loss in maize due to stem borers. He particularly noted the regular updates to the stakeholders on the project's progress. He indicated that the Director-KARI was very interested in seeing the project achieve its goals in Kenya and that those achievements be extended to other parts of Africa.

Dr. Joseph Wanjama, Director of Agriculture, Ministry of Agriculture and Rural Development(MOARD), officially opened the meeting. He indicated the importance of maize in Kenya in terms for national food security, and the resultant importance of the IRMA project. Dr. Wanjama noted that with its increasing population, Kenya requires an additional 2-3 million tons of maize annually. The government policy is to assess and, when warranted, promote the use of new technologies, including genetic engineering, while ensuring the safety of the people and the environment. With biosafety protocols already operational in Kenya and adherence to them strictly followed, the government was indeed fulfilling its mandate to ensure the overall safety of this promising technology. Dr. Wanjama expressed his appreciation for the collaboration amongst KARI, CIMMYT, and the Syngenta Foundation in the development of Bt maize for the benefit of Kenya and sub-Saharan Africa. He asked that farmers and other stakeholders be patient while the scientists continue to develop the new technology.

Dr. Stephen Mugo, coordinator of the IRMA project, made a presentation on the project's progress to date. Dr. Mugo emphasized that the goal of the IRMA project was to increase maize production and food security through the development of insect resistant maize. He highlighted the fact that the Kenyan population is increasing at a rate of 3% annually while maize production has only been increasing by 1.5%. Since there is little arable land not already under cultivation, he said, the only option is to intensify agriculture, which unfortunately also brings increased pest/disease pressure on crops. In maize, the most critical pests are stem borers, which cause yield losses of about 15%, valued at US$ 76 million. The advantages of the Bt technology are that it offers in-built resistance to stem borers, thereby alleviating the need for farmers to purchase insecticides for borer control, and that the technology is carried in the seed. He highlighted the methodologies that were being used to develop the insect resistant maize, including screening of diverse germplasm for resistance to stem borers and screening Bt genes for effectiveness against different stem borer species.

Dr. Mugo reported that the project is addressing environmental issues such as management of insect resistance, impact to target and nontarget organisms, and capacity building through training, sensitization workshops, creation of increased farmer awareness and enhanced communication between scientists and the media. Dr. Mugo concluded his presentation by informing the participants that all IRMA activities will ensure that the improved maize variety with insect resistance will be put in farmers hands in the form of seed, which will be adapted to the Kenyan ecozones and tolerant to other common stresses.

Dr. Andrew Bennett, the Executive Director of the Syngenta Foundation for Sustainable Agriculture noted that the IRMA project is a partnership amongst public, private, and civil society. He said that none of the collaborators had all of the resources and skills needed to address the major maize production problems in Kenya; therefore, partnerships are required. He said the Syngenta Foundation is interested in providing people with public goods and that it believes in giving people options from which to choose. In the case of the IRMA project, new varieties should be obtained from both conventional selection and through incorporation of Bt genes. Dr. Bennett said he was very impressed with the IRMA project, noting that it is a classic example of good practice—trying to do things right by giving farmers choices and bringing together the private and public sectors to achieve that goal. He said that working with genetically modified organisms clearly requires capacity building and that IRMA has performed well in this regard. However, in the future, other parties will need to be brought in to enhance funding to support capacity building and to promote acceptance of the technology.

Dr. Bennett said the Syngenta Foundation was keen to remain engaged in the project until its completion and he encouraged stakeholders to continue to advise the IRMA scientists to keep them on the track of developing maize that will be welcomed in communities around Kenya. Dr. Bennett concluded by saying that agricultural policies are changing and are becoming more conducive to African countries obtaining access to technologies and increasing their markets. He said that the Syngenta Foundation is happy to be associated with IRMA and the development of technology that will improve the livelihood of the Kenyan people.

In his speech, the Director General of CIMMYT, Dr. Masaru Iwanaga, said he enjoyed the opportunity to meet the Kenyan scientists who were involved with the Bt technology, which would improve the livelihood of farmers in Kenya. He noted that no single institution could take on a project with the scope of

IRMA by itself and that he was heartened by the strong collaboration amongst CIMMYT, KARI, and the Syngenta Foundation. He said that it is evident that the IRMA project is steadily approaching its goal of deploying stem borer resistant maize and that Kenya is leading the way in sub-Saharan Africa in developing such varieties. He said stakeholder input was an essential element in developing a technology that would be confidently adopted by farmers. Dr. Iwanaga concluded by saying that it will be up to the farmers to ensure that the technology lasts by following the recommended management practices, and that if Bt technology is successful in Kenya, then Kenya will serve as a model to other African countries.

The stakeholders engaged the presenters experts panel in the question and answer period. As in past stakeholders meetings, questions were varied, ranging from points about the management of research directed to the Ministry of Agriculture to specifics on the IRMA project. Many questions related to the stewardship of the technology. This is an indication that the basics of the technology are now understood by the representatives of our stakeholders, in that they are moving on to post-deployment questions. As in the past, there were questions from farmers about when the new technology would be available and what was the cause of the delay.

In follow-up discussions it was determined that there will be an increased emphasis on consumer involvement and a concerted effort will be made to invite consumer groups and market outlets such as grocery store chains, millers, and manufacturers of corn oil products.

Many people contributed to the success of the Third IRMA Stakeholders Meeting. We especially appreciated Dr. Kedera for the excellent chairing; Dr. Wanjama for the official opening, Dr. Iwanaga for reiterating CIMMYT's commitment, and Dr. Bennett for assuring continued support to the IRMA project. We recognize the input of the CIMMYT and KARI scientists who took part in planning and driving the project. We also wish to thank all of the stakeholders for attending the meeting and for offering suggestions on what needs to be done to ensure success. Finally we acknowledge the role of Mrs. Ebby Irungu and Priscilla Muisyo for their invaluable logistical support and the Hilton Hotel staff for ensuring the success of the meeting.

Stephen Mugo
Coordinator, IRMA Project, CIMMYT, Kenya

CIMMYT Director General Masa Iwanaga addresses the Third IRMA Stakeholders Meeting in Nairobi, Kenya.

IRMA Project in Brief

Introduction

The goal of the Insect Resistant Maize for Africa (IRMA) project is to increase maize production and food security through the development and deployment of insect resistant maize that will reduce losses due to stem borers. The project is a joint venture between the International Maize and Wheat Improvement Center (CIMMYT) and the Kenya Agricultural Research Institute (KARI), with financial support from the Syngenta Foundation for Sustainable Agriculture. It responds to the need to feed the rapidly increasing population of sub-Saharan Africa by tackling one of the major sources of maize crop losses in southern and eastern Africa—stem borers. Lepidopteran stem borers are economically important pests of maize, a major staple in Kenya, with losses estimated losses at US$ 76 million. Both host plant resistance and genetically engineered maize (e.g., Bt maize) have been identified as possibilities to help resource poor farmers combat stem borer damage and meet their food requirements. The project focuses on identifying the best methods to properly combine these mechanisms and ensure that Kenyan farmers will be able to take advantage of modern approaches to this problem.

Goals and Objectives

The overarching goals of the project are to develop insect resistant maize varieties for the major Kenyan maize growing environments, and to establish procedures to provide insect resistant maize to resource poor farmers in Kenya. During the implementation of the IRMA project, relevant technologies will be transferred to KARI and continuously evaluated.

The specific objectives of the project are as follows:

1) *Product Development:* Develop insect resistant maize varieties for the major insect pests found in Kenyan maize production systems;
2) *Product Dissemination:* Establish procedures for providing insect resistant maize to resource poor farmers in Kenya;
3) *Impact Assessment:* Assess the impact of insect resistant maize varieties in Kenyan agricultural systems;
4) *Technology Transfer:* Transfer technologies to KARI and Kenya to develop, evaluate, disseminate, and monitor insect resistant maize varieties; and
5) *Project Documentation and Communication:* Plan, monitor, and document processes and achievements for dissemination to the Kenyan public and developing countries.

IRMA Project Highlights in 2002

Product Development

The main activities related to the transgenic component of product development were initiation of the design and contract approval process for a level-2 biosafety greenhouse complex at KARI-NARL, issuance of a permit to introduce Bt maize leaves from first generation events and combinations of these events to test the efficacy of two-gene combinations in controlling Kenyan stem borers, establishment of an open quarantine site (OQS) and initiation of operations at Kiboko, growing of two sets of mock trials at the OQS for training staff and collaborators on management of OQS facilities. Other activities were the derivation of full molecular characterization and protein expression in different plant parts of second generation *Bt* events (6 *ubi:cry1B*, 2 *ubi:cry1Ab* and 1 *act:cry1Ab*). The acquisition of two new synthetic *Bt* genes; *cry2A* from Canada and *cry1C* from CIRAD, which will be combined with the Ubi & Act promoters to produce transformed events to evaluate against African insects. Efforts continue to develop additional second generation *Bt* events, including *act:cry1B*, *ubi & act:cry1Ab*, *ubi & act:cry2A*, and *ubi & act:cry1C*. The mannose selection technique is being evaluated and is in the process of being utilized.


Dr. E. A. Mukisira, Deputy Director, KARI, examines transgenic maize plants in the CIMMYT biosafety greenhouse in El Batan, Texoco, Mexico.

Product development activities using conventional breeding techniques focused on producing insect resistant maize germplasm adapted to Kenyan agroecological zones. A key activity was , the screening of putative source germplasm from CIMMYT-Mexico, Zimbabwe, and Kenya. A total of 862 maize inbred lines were evaluated and advanced. Resistant inbred lines and open pollinated varieties (OPVs) were identified and are being used to develop stem borer resistant germplasm. Forty S6 insect resistant inbred lines from the MBR group were identified for development of insect resistant germplasm, including hybrids and OPVs. Diallel crossing studies are underway to investigate the combining ability of IR lines in order to identify good general combiners for use in OPV development and good specific combiners for hybrid development. One hundred and eighty (180) single cross and 60 3-way cross hybrids were developed from elite insect resistant maize inbred lines and evaluated across locations for tolerance/resistance to insects, diseases, random drought and low nitrogen stresses, and for yield potential and general adaptation. More than 400 elite maize hybrids from CIMMYT were evaluated to identify good prospects for Kenyan conditions.

Product Dissemination

Research in this area focused on the development of appropriate insect resistance management strategies for resource poor farmers in Kenya. Evaluation of putative species for refugia at Mwapa, Embu, Kakamega, and Kitale, indicated that various sorghum varieties and wild Columbus and Sudan grasses were effective refugia. A vegetation survey protocol for insect resistance management (IRM) was developed to quantify the distribution and abundance of alternate hosts for maize stem borers in Kenya, by estimating the percent area planted to maize relative to alternate host species for stem borers and their proximity to each other. Results from Mtwapa surveys showed that there is a 21% refugia area within the existing cropping system. However, in the Trans-Nzoia district, maize is grown predominately as a monoculture and the natural refugia is inadequate. For this region, a structured refugia will be required, in which the seed industry and extension officers will need to work with researchers in educating farmers on the importance of refugia to maintain the effectiveness of Bt maize. Surface maps are being generated to identify areas that pose a high risk of resistance development.

Field collections and sorting of samples from research on characterization of target and nontarget arthropods of *Bt* gene-based resistance in four major maize growing regions in Kenya were completed. Digital photos were taken of a representative number of specimens, and entered into a database for easy access by regional offices. Core and reference insect collections have been established at KARI-Katumani. Collection data is now being formatted for use in a GIS context to facilitate monitoring efforts following the introduction of Bt maize.

A study was conducted on the nontarget effects of a Bt biopesticide (Thuricide™) and conventional insecticides (Dimethoate) on arthropods in a maize/bean cropping system. Results showed that Thuricide provided more effective stem borer control than Dimethoate. Dimethoate had a more adverse impact on nontarget arthropod diversity (families) and abundance.

Screening trials using two *Diatraea spp.* of stem borer showed that they have not developed resistance to *cryIAb* after 30 cycles of selection.

Screening for resistance to weevils was conducted for all trials used for germplasm improvement and putative resistance genotypes were identified. Resistant sources from CIMMYT-Zimbabwe and CIMMYT-Mexico will be incorporated into locally adapted germplasm.

Impact assessment

Activities in this area include the initiation of baseline data collection and biodiversity analysis of the PRA data, which showed the high potential areas to be richer in maize biodiversity than the dry areas. Analysis of the maize seed industry found that the liberalization has largely increased the number of seed distribution points and to a lesser degree the number of seed producers. A study of informal credit groups showed that members who borrowed from the group significantly used more inorganic fertilizer and improved maize seed and obtained a significantly higher output. A study on farmer seed recycling was initiated at Embu and Kitale to determine the economics of this common practice. An inventory on NGOs working in agricultural activities showed that these can complement conventional agricultural extension but cannot replace conventional extension.

Technology Transfer

Considerable emphasis was placed on training in the areas of biosafety and genetic engineering. Two scientists from KARI initiated training at CIMMYT-ABC in Mexico in transformation and molecular analysis. Three scientists from KARI and KEPHIS were trained on management of biosafety facilities at CIMMYT-Mexico. KEPHIS and KARI scientists trained ten Kenyan scientists on management of open quarantine field facilities. Six management level Kenyan scientists from KARI, KEPHIS, and the Ministry of Agriculture and Rural Development, together with CIMMYT scientists, visited institutions dealing with biotechnology and biosafety facilities in the USA and Mexico. One entomologist from KARI visited CIMMYT-Zimbabwe to observe activities in the maize weevil resistance breeding project there and learned about methods and recent research results for weevil resistance in maize.

Documentation and Communication

A major new thrust in this area in 2002 was increasing awareness about Bt technology and its associated components (e.g., refugia) among key extension staff of the Ministry of Agriculture and Rural Development (MOARD). Seminar/workshops were held in July for lead extension staff in the major maize growing regions of Kenya. Approximately 120 resource persons and extension personnel attended the seminars. Additional objectives of the seminars were to ascertain information gaps that the project needs to address, identify particularly good communicators among extension staff, identify particularly effective messages related to Bt for possible later use in video and/or radio productions, and field test/refine six IRMA fact sheets on various aspects of Bt maize and its management.

IRMA scientists also gave presentations and/or participated in a wide range of seminars including "Potential Contributions of Biotechnology to Sustainable Development: Examples from the IRMA Project," (S. Mugo) at the WSSD for Regional Parliamentarians and Policy Makers, and presentations at the symposium "Perspectives on the Evolving Role of Private/ Public Collaborations in Agricultural Research" organized by the Syngenta Foundation for Sustainable Agriculture (J. Songa and S. Mugo). The presentations were also made to the Syngenta staff in Greensboro, NC, USA, and to the Syngenta staff in Basel, Switzerland.

Two IRMA Project documents were produced: the 2001 Annual Report and the 2001 Stakeholders Meeting. The IRMA Updates quarterly newsletter was produced, about 200 hardcopies were distributed, mostly in Kenya, and it was posted on the IRMA website. Monitoring of the print media continued through the clipping service and periodic review of the reports. Approximately 100 articles and 30 editorials related to agricultural biotechnology, mostly maize, appeared in the major Kenyan newspapers during 2002. Five feature type articles had an IRMA focus. Slightly less than half of the total articles and editorials were related to GM maize and the food crisis in southern Africa.

Eight technical presentations were made to the 7th Eastern & Southern Africa Regional Maize Conference and Symposium on Low-Nitrogen and Drought Tolerance held in Nairobi, Kenya.

Project management

The IRMA project is implemented and managed through a steering committee composed of Senior Directors from CIMMYT, KARI, and the Syngenta Foundation and chaired by the CIMMYT project director (the Director of the Applied Biotechnology Center and Bioinformatics). Co-coordinators for CIMMYT and KARI provide the operational management of the project with the assistance of a Project Coordination Committee. CIMMYT has based a maize breeder in Kenya to develop suitable maize germplasm through backcrossing of the various insect resistant genes into Kenyan germplasm. A CIMMYT economist, based in Kenya, is implementing the impact assessment activities. As information is a major output of the project, a CIMMYT communication expert has been designated to assist in preparing project documents, mainly related to public education and public/media relations issues. The project is supported at CIMMYT headquarters by a cell biologist and an entomologist, as well as other staff in the Applied Biotechnology Center, Maize Program, Economics Program, and Information and Multimedia Services.

Program

Chairman: Dr. John Kedera, Managing Director, KEPHIS

Rapporteurs: Dr. M. Mulaa (Entomologist KARI), Mr. P. Likhayo (Entomologist KARI), and Mr. H. Karaya (Msc. Student, Nairobi University).

11.00 am	Arrival and registration, Mrs E. Irungu, Administrative Assistant, CIMMYT-Kenya
12.30 pm	Lunch
2.00 pm	Welcome and Introductions, Dr. J. Kedera, Director, Kenya Plant Health Inspectorate Service (KEPHIS).
2.25 pm	Official Opening speech, Dr. Wanjama, Director Of Agriculture and Livestock production, Ministry of agriculture and Rural Development.
2.45 pm	IRMA status and Progress in 2002, Dr. S. Mugo, Coordinator, IRMA project, CIMMYT-Kenya.
3.20 pm	Remarks by Syngenta Foundation for sustainable Agriculture, Dr. A. Bennett, Executive Director, Syngenta Foundation for sustainable Agriculture.
3.40 pm	Remarks by CIMMYT, Dr. M. Iwanaga, Director General, CIMMYT.
3.55 pm	Remarks by KARI, Dr. J. Ochieng, Assistant Director Food Crops, KARI.
4.15 pm	Question and answers session, all participants
5.00 pm	Cocktails

S. Mugo presents an overview of the IRMA project to the 2002 Stakeholders' Meeting.

Welcome and Introductions

Dr. John Kedera, Director, Kenya Plant Health Inspectorate Service.

Dr. J. Kedera, Director of the Kenya Plant Health Inspectorate Service (KEPHIS) chaired the meeting. The Chairman welcomed all participants to the stakeholders meeting and requested that participants introduce themselves. Participants who attended the meeting represented diverse institutions, organizations, and farmer groups, and included representatives of government institutions, non-governmental organizations, seed companies, environmental groups, regulatory agencies, universities, community-based organizations (CBOs), the media, the donor community, international research organizations, collaborating institutions (KARI and CIMMYT) and the major donor to the IRMA project (Syngenta Foundation for Sustainable Agriculture). The chairman also introduced the chief guests and recognized the presence of Dr. Masa Iwanaga, Director General of CIMMYT and Dr. Andrew Bennett, Executive Director of the Syngenta Foundation for Sustainable Agriculture.

Official Opening Speech

Dr. J.K. Wanjama, Director of Agriculture and Livestock Production.

Workshop organizers, participants, ladies and gentlemen:

I take this opportunity to welcome you all to this Third Stakeholders Meeting of the Insect Resistant Maize for Africa project, known more generally by its acronym, the IRMA project. I would like to especially recognize the presence of Dr. Masa Iwanaga, the new Director General of the International Maize and Wheat Improvement Center, Dr. Andrew Bennett, the Executive Director of the Syngenta Foundation for Sustainable Agriculture, and Dr. Klaus Leisinger, the Executive Director of the Novartis Foundation for Sustainable Development—all of whom are our project partners.

Ladies and gentlemen, since the public launch of the IRMA project with its first stakeholders meeting in March 2000, we have seen many changes in the world around us. We have seen the actual physical landscape change as the impacts of global climate change intensify. Large parts of the ice shelves of Antarctica have broken free and the snows are retreating on our very own Mt. Kilimanjaro. We have also seen man trying to solve the problems he has created through his activities, which culminated in the recent meeting of World Summit in sustainable development held in South Africa.

On a more positive note, we have seen some incredible scientific progress, such as the sequencing of the human genome, which has revealed how similar we really are in our genetic makeup, not just among the human species, but also with all living organisms. As the knowledge generated from research is applied to new technologies, we will surely see tremendous leaps in treating diseases and disorders of all kinds caused by biotic and abiotic factors.

But unfortunately, one thing that has not changed since that first Stakeholders Meeting is the lack of food security in sub-Saharan Africa and right here in Kenya. Famine and hunger are once again visiting our continent and many of southern African nations are affected. Though we have recently had a very good harvest, we know all too well that food shortages, particularly of maize, have not been banished from Kenya. The maize crop in Kenya is of particular importance and many citizens believe there is no *food* if maize is not available. The maize requirement currently in sub-Saharan Africa stands at 100 kg per capita per annum while Kenya's average consumption is 125 kg per capita per annum. It's worth noting that maize production in this country is supported primarily by small-scale farms, which range in size from 0.51.0 ha in the high/medium potential areas that account for only 20% of Kenya's land mass.

This situation combined with increasing population means that food and particularly maize needs to be produced in more innovative ways. In the past, food production requirements had been met through intensive production, which included, among other things, the widespread adoption of hybrid maize in the country. Currently, most yield increases for food crops have stagnated. Due to the high cost of inputs, farmers cannot optimize the gains provided by most of the available varieties. Climatic conditions are becoming more erratic and less predictable, further challenging our ability to feed ourselves in coming years, and in fact we have already witnessed an overall trend of reduced food availability for Kenyans on a per capita basis.

Unfortunately, crops under intensified production systems usually face increased pest pressure. *Striga* and stem borers have accompanied greater intensification and are taking a high toll on what should be higher productivity. Finding ways to cut those losses represents a direct path to increasing farmers' yields, which not only puts more food on Kenyan tables, but also helps address our primary social concern, poverty. Stem borers in particular have posed serious challenges to maize production in Kenya, occasioning an estimated loss of 15% in maize grain yield or up to 100% when compounded by drought. These losses are reinforcing projects that indicate that sub-Sahara Africa requires an additional 2-3 million tons of maize annually to meet its needs.

Ladies and gentlemen, the aforesaid presents a challenge to our scientists to use their talents to develop maize varieties with genetic resistance to stem borers to increase productivity and reduce pesticide use, expense, and labor requirements. Conventional breeding methods to achieve this objective have proven to be time consuming, taking up to 12–15 years, but through the modern science of genetic engineering this period can be reduced considerably.

The need to achieve increased food production for Africa, including Kenya, created the need to get into partnerships such as that seen in the Insect Resistant Maize for Africa (IRMA) project, which examines the use of biotechnology to address maize loss through stem borers by developing Bt maize that produces insecticidal proteins from genes derived from *Bacillus thuringiensis*, a soil bacterium.

Ladies and gentlemen, the government policy on biotechnology is, like in all sciences, to embrace new and proven technologies, including genetic engineering, while assuring the safety of the derived products to the consumer and the environment. Biotechnology in this country is being handled by competent scientists on a case-by-case basis through the Biosafety Protocol, which is already in operation. As you are aware, the responsibility of governments is to ensure the welfare and safety of its citizens and so we will only release materials to our people and environment after a thorough risk assessment. It is also worth noting that as far as Bt maize is concerned, the USA has produced and used Bt maize since 1996, and to date there are no adverse effects on its use and introduction into the environment. Given the importance of maize—both at the farmer and national levels—it is clearly in our interest to pursue new approaches and technologies for increasing yields in ways that preserve our natural resource base, and that are also viable for farmers, particularly the resource poor farmers.

Finally ladies and gentlemen, allow me to express my appreciation of the partnership and collaboration amongst the Kenya Agricultural Research Institute (KARI), CIMMYT, and the Syngenta Foundation, which will result in the development of new varieties of Bt maize with novel traits, which we hope will benefit the Kenyan farmer and the rest of the sub-Saharan Africa. To the farmers, we still require your patience to allow us finalize the science before we release the material to you in the near future. With these remarks, I now wish to declare the workshop officially opened. Thank you.

IRMA Project, 2002: Status and Progress

Dr. Stephen Mugo, Coordinator IRMA Project, CIMMYT-Kenya.

Dr. Joseph Wanjama, Director of Agriculture and Livestock Development,
Dr. Masa Iwanaga, Director General, CIMMYT,
Dr. Joseph Ochieng, Assistant Director, Food Crops, Kenya Agricultural Research Institute (KARI),
Dr. Andrew Bennett, Director, Syngenta Foundation for Sustainable Agriculture,
Dr. John Kedera, Director, Kenya Plant Health Inspectorate Service (KEPHIS),
Dr. Dr. David Hoisington, Director CIMMYT ABC,
Farmers,
Distinguished IRMA stakeholders, KARI and CIMMYT scientists,

Good afternoon ladies and gentlemen and welcome.

I welcome you to the third stakeholders meeting and wish to present the status and progress of the Insect Resistant Maize for Africa (IRMA) project. Our goal remains the same as before: to increase maize production in Kenya through the development and deployment of maize varieties resistant to insects.

Many African countries still face the challenge of producing sufficient food for the ever-increasing population, estimated to increase by 3% annually while food production increases by only 1.5% annually. Obtaining food self-sufficiency is therefore an urgent part of the development agenda for many countries in sub-Saharan Africa, including Kenya.

Once again I wish to remind you of the major constraints to increasing food production in Africa and Kenya. These are inadequate rainfall, low soil fertility, pests, and diseases. Faced with these same constraints, our ancestors relied on shifting cultivation, including bush fallows. We do not have the luxury of new land and so our only option is intensive cultivation. As with most things in nature, intensification requires more inputs and it also brings on increased pest and disease pressures. Using pesticides to combat pests and diseases is expensive, time consuming, and potentially damaging to the environment and human health. Stem borers, in particular, have proven to be especially damaging to maize production.

IRMA's impact assessment group of social scientists have focused on assessing various aspects of insect losses, suitability and demand of the new insect management technologies, farmers' perceptions of crop losses and control options, and assuring that the technology fits within Kenya's institutional framework. Through continuous dialogue with different stakeholders such as environmental groups, local research institutes, seed companies, and above all the farmers, IRMA has gained a clearer understanding of social, environmental, and economic impacts of insect resistant maize in Kenya. These activities continued in 2002. Baseline data collection established a reliable record of the status of maize farming in Kenya. Analysis of biodiversity from data collected during the Participatory Rural Appraisal shows that the high potential areas are richer in biodiversity in maize than the dry areas, and that in the dry areas the most popular varieties are also more dominant. The highlands clearly face more dominance (caused by the very popular H614 variety) than the other high potential area, the moist transitional. The coast and the Lake Victoria basin have more local varieties than the other zones.

A study on the maize seed industry found that liberalization has greatly increased the number of seed distribution points, and to a lesser degree the number of seed producers. New companies and new varieties have made considerable progress in the moist midaltitudes, but not so in the highlands and low-potential areas.

A study of informal credit groups in Siaya district showed that members who borrowed from the group significantly used more than three times as much inorganic fertilizer and double the quantity of improved seed as those who never borrowed. They nearly doubled their maize production over their counterparts, indicating the contribution of informal credit system to maize production.

A study on farmer seed recycling was conducted at Embu and Kitale to determine the economics of this common practice. It showed that grain yield decreased with the recycling of maize hybrids. A study of NGOs working in agricultural activities at the coast showed that NGO extension efforts can complement conventional agricultural extension and can be important at the local level, but are limited in comparison to conventional extension.

A study on consumer awareness about the GMO issue in Nairobi showed that very few urban consumers have knowledge about genetically modified organisms (GMOs), and that GMOs would not, at the moment, influence their consumption pattern. Most of the highly educated group, university professors, were informed about GMOs.

Follow-ups to the Participatory Rural Appraisals were conducted, which involved 900 farmers in the five maize growing ecological zones of Kenya; they identified farmers' preferences for maize varieties and the constraints they face. Those studies revealed that most farmers plant local varieties in the low-potential areas while improved varieties dominate the high-potential areas. The most important selection criteria are early maturity and yield, followed by drought tolerance, then tolerance to field and storage pests. The major constraints to maize production were availability of cash, lack of technical know-how, and availability of good quality seed. The major pest problems, according to farmers, are stem borers and weevils. Farmers show a keen interest in new insect resistant varieties if they fit their selection criteria, even if they are moderately more expensive. However, since seed supply and quality are problems, the quality of seed needs to be guaranteed.

Studies on crop loss due to stem borers showed that Kenya losses an average 15% of its maize crop annually, with a value of US$ 76 million. Crop loss assessment will be a continuous exercise in IRMA project to ascertain losses experienced by farmers.

Stem borers remain the most widely distributed and most damaging pests to maize worldwide. In Africa, there are several economically important stem borer species. In Kenya, the most important borers are the spotted stem borer (*Chilo partellus* Swinhoe) and the African stem borer (*Busseola fusca* Fuller). *Chilo partellus* is found mainly in East Kenya, and is the most destructive pest of maize in warm, low-altitude regions. *Busseola fusca is* mainly in West Kenya, is native to Africa, and is the major borer pest in the highlands. A very important aspect of the IRMA project is that the work carried out by KARI and CIMMYT will be used to help other African countries in the region combat maize stem borers. The IRMA project will be working in all maize production regions to develop maize varieties that both offer resistance to the most important stem borers in a given region and also produce good yields under local growing conditions. We plan to make the experiences and lessons learned—and some of the maize germplasm that we develop in this project—available to those of our neighbors that want to use this technology themselves.

The stem borer life cycle starts out with the adult moths depositing their eggs on the leaf of the maize plant. The eggs hatch and the emerging larvae feed on the leaves and the whorl of the maize plant. They feed on the whorl for approximately 10 days, and then start to tunnel into the stalk of the maize plant. In the case of *C. partellus*, the larvae are actually able to kill the plant during the early stages of crop development—this is referred to as "dead-heart" and results in complete yield loss. Stalk tunneling is also a destructive stage as it reduces grain yields and the larvae are virtually invulnerable to insecticides applied to the outside of the plant, and are actually protected from birds, parasitoids, or other natural control measures. Larvae can also attack maize ears, creating a wound for diseases that produce toxins (aflatoxins, fumonisins), which are dangerous to humans.

There are four general approaches to insect control: (1) chemical control by application of insecticides, which can be a health risk and can contaminate the environment; (2) biological controls that attack stem borer eggs, larvae, and pupae, but may require trained personnel for identification and deployment and commitment of the farming community to promote biological controls; (3) cultural control, which includes a broad range of field and crop management techniques that are combined with other control practices; and (4) host plant resistance, by which the plant itself is resistant to the stem borers. For reasons of cost and labor, farmers often resign themselves to using no control measures at all.

Host plant resistance is transferred to farmers in the seed, a fact that ensures that the technology is inexpensive, safe, and that the farmers need not purchase more inputs to control stem borers. Use of stem borer resistant maize increases efficiency of farming by reducing or eliminating the expense of insecticides and reducing yield losses from stem borer damage. For resource poor, small-scale farmers in developing countries, the great emphasis on control of stem borers is through host plant resistance packaged into improved varieties that offer a practical and economic means of minimizing stem borer losses.

The IRMA project is primarily focusing on developing stem borer resistant maize varieties, first for Kenya and later to other interested African countries. The development of these varieties is based in part on utilizing genes and sources of resistance already existing in the maize plant, through conventional breeding methods. The search for stem borer resistant maize germplasm has led to testing of numerous maize genotypes from KARI, CIMMYT-Kenya, CIMMYT-Zimbabwe, and CIMMYT-Mexico. This germplasm is also screened for tolerance to local stresses such as drought, low-nitrogen, resistance to maize streak virus, northern leaf blight, leaf rust, and weevils in storage in a way that ensures that we combine the *good* of insect resistance to the *good* of adaptation and resistance to common stresses found in farmers' fields. Through breeding efforts, we are identifying promising hybrid and open pollinated varieties with insect resistance to more than one stem borer species The varieties are showing superiority in grain yields and in insect resistance when compared with local checks. However, the resistance is still low and other control measures are being sought.

We are using genetic engineering, a branch of biotechnology, whereby a gene normally found in soil-dwelling bacteria, *Bacillus thuringiensis*, or Bt, is moved into maize. This family of genes codes for toxins that are highly specific to certain groups of caterpillar pests, but harmless to most other insects and to animals and humans. In fact, "organic" farmers have used Bt sprays for years because it is natural and safe. Biotechnology has allowed us to take the genes from the bacterium, modify them to function optimally in various crop species, and then transfer them into maize and other crops, where they provide protection against many types of insect pests. This technology has seen rapid adoption in industrial and developing countries. Last year, in 2001, the acreage rose to 40 million hectares in the developed countries, and 12 million hectares in developing countries, where a slower but steady rate of adoption was observed.

In 2001, we have evaluated various *Bt* genes expressed in transformed maize and identified some that are effective against Kenyan stem borers. This December [2002] we will evaluate cross combinations of those *Bt* genes after obtaining a permit to introduce maize leaves with the desired genes. As we did last year [2001], leaf tissue from maize plants planted in the CIMMYT Applied Biotechnology Center's biosafety greenhouses in Mexico will be brought to Kenya, following the strict procedures for handling transgenic materials established by the Kenya National Biosafety Committee.

Insect bioassays will be used to determine the control provided by the different genes by allowing five young larvae from each of the targeted pests to feed on leaf tissue for five days. By using leaf tissue for the experiment, the scientists ensure that no seed or living maize plants could inadvertently "escape" into the environment before the necessary environmental studies have been conducted.

The results obtained last year showed that the *Bt* genes tested (*cry1B*, *cry1Ab*, and *cry1Ab-1B)* were lethal to spotted stem borer (*C. partellus)* and coastal stem borer (*Chilo orichalcocililiellus)*. African pink borer (*Sesamia calamistis)* and African sugarcane borer (*Eldana saccharina)* were killed by *cry1Ab-1B* and *cry1Ab*. The African maize stem borer (*B. fusca)* was not adequately controlled by the genes tested, indicating the need to look for other genes and/or combinations of genes to target this borer. A prospective control for the most destructive borer, the spotted stem borer, which is also the most widely distributed stem borer in Kenya, was identified. Further work is therefore needed to develop an effective control for the African maize stem borer.

We embarked on a search for prospective controls for this stem borer and this year we have acquired two more genes (*cry2A* and *cry1C*), and have started to transform maize in a search for an effective control. We also embarked on training Kenyan staff on the new science of transformation and in biosafety, as I will report later.

As with any new product, thorough and proper testing is necessary. We must evaluate the effects of Bt maize on the environment. We are also concerned with the pests building up resistance to the Bt maize and rendering it less effective. To minimize any potential adverse effects, IRMA has decided to develop "clean" Bt maize events that carry only the gene of interest. These carry neither the selectable Basta™ herbicide resistance (the *bar* gene) marker nor antibiotic markers. The *Bt* and *bar* genes are kept separate (co-transformed) to increases the likelihood of separating the two genes in the final product. While requiring additional laboratory work, we believe this approach is critical in demonstrating that the project is acting responsibly in developing state-of-the-art techniques to produce safe and effective Bt maize varieties for farmers in Kenya. We are now developing molecular maps of these clean events.

This year, we developed a full molecular characterization of the second generation *Bt* events, and studied the protein expression in different plant tissues to ensure that the endotoxins are produced where insects are feeding, on the leaves. All these activities are geared toward ensuring that the products availed to Kenya will be effective and well tested.

To counter the build-up of resistance by the borers to Bt maize, we will develop varieties that carry multiple forms of resistance, for example, multiple *Bt* genes and combinations of *Bt* genes, as well as conventional resistance. This means a borer population would have to develop multiple resistances rather than a single resistance to the Bt. In addition, management strategies will be developed, with the help of farmers, that maintain populations of non-resistant borers that will breed with potentially resistant borers and limit the build-up of resistant populations. Any host of the borers can be used for this purpose and taken collectively they are known as "refugia."

Studies were initiated to develop insect resistance management strategies for Kenyan ecosystems based on existing cropping systems. To be accepted by farmers, insect resistance management strategies must conform to existing cropping systems, and the refugia crops must be economically viable and socially acceptable to those making the management decisions at the farm level. Studies focused towards verifying these tenets were also initiated. After evaluating 30 different alternate hosts, including sorghum, millets, fodder grasses such as napiers, and wild alternate hosts (mainly thick stemmed grasses), results showed that sorghum and Columbus and Sudan grasses were the most effective refugia for *C. partellus* and *B. fusca*. Wild Columbus and Sudan grasses were effective refugia, generating 4 and 2.5 times as many moths as maize sorghum were the best hosts for *C. partellus* and *B. fusca*, given the large number of exit holes per stem and numerous tillers. Napier grasses attracted oviposition, but were not good hosts for larval development.

An exciting activity in 2002 was a vegetation survey protocol carried out to quantify the distribution and abundance of alternate hosts for maize stem borers in Kenya. We aimed at estimating the percent area planted to maize relative to alternate host species for stem borers and their proximity to each other. With this information, we can identify regions where a natural refugia is sufficient to obtain the 20% maize equivalents recommended by IRM specialists. The survey was carried out in Trans-Nzoia district in the highlands and in Kilifi in the humid coastal lowlands. Results indicated that in Mtwapa there is a 21% refugia area within the existing cropping system. If 20% of the area were planted to non-Bt maize, this would provide a total of

32% refugia. However, in the Trans-Nzoia district, maize is grown predominately as a monoculture and the natural refugia is not adequate. Therefore, for this region, a structured refugia will be required, in which the seed industry and extension officers will need to work with researchers in educating farmers on the importance of refugia to maintain the effectiveness of Bt maize. To this end, extension brochures (fact sheets) have been prepared in draft form to inform extension agents, seed companies, and farmers about Bt maize and the stewardship of the technology. Surface maps are being generated to identify areas that pose a high risk of resistance development, to ensure that these areas are surveyed.

On environmental impact, we are committed to determining what—if any—effects transgenic maize will have on our precious ecosystems. Research has focused on establishing the diversity and relative abundance of target and nontarget organisms that could potentially be affected by the introduction of Bt maize into Kenya's major maize cropping systems. Using pit-fall traps to trap soil crawling arthropods, water traps and sticky traps for flying arthropods, and by destructive sampling to recover organisms on and in the plant, the diversity of organisms associated with maize cropping systems were recovered, characterized, and, catalogued and will serve as a technical reference during the monitoring phase of the IRMA project. These studies were carried and completed in all five maize growing ecologies, and the organisms collected, characterized, quantified, and specimens preserved as core and reference collections. Digital photographs and passport data with details on origin were kept. These will all be important during the monitoring phase of the project.

Screening trials using two *Diatraea spp.* of stem borer have not developed resistance to *cryIAb* after 30 cycles of selection. This study, conducted in Mexico, indicates that for this type of insect, resistance has held up well under an ideal selection regime. However, this may not be the case for other types of insects, and this kind of selection trial will be carried out on Kenyan stem borers once the biosafety greenhouse in NARL is operational and Bt maize plants are available.

A study evaluating Bt-biopesticide and conventional insecticides for the management of stem borers and the nontarget effects on arthropods in a maize/bean cropping system revealed that Bt-spray was more effective in controlling stem borers, while preserving a greater number of parasitoids compared to synthetic insecticide treated plots.

Following stakeholders requests, we have including screening for weevil resistance in our variety evaluation research as well as gathering weevil resistant maize in our collections, as value-added activities in the project.

In any undertaking involving new technology, technology transfer and capacity building in local institutions is critical to success and sustainability. Training of KARI scientists was done in Mexico and on-site in Kenya. Two KARI scientists are currently training on genetic engineering in CIMMYT-Mexico. Three scientists from KARI and KEPHIS were trained on management of biosafety facilities at CIMMYT-Mexico, while ten others were trained on management of open quarantine field facilities by KEPHIS staff. Six management level Kenyan scientists from KARI, KEPHIS, and the Ministry of Agriculture and Rural Development, together with CIMMYT scientists, visited institutions dealing with biotechnology and biosafety facilities in the USA and Mexico. Visits in the United States were made to USDA, FDA, EPA, and Syngenta, and in Mexico to CINESTAV, INIFAP, CIBIOGEM, Sanidad vegetal, and CIMMYT. The delegation familiarized themselves with existing facilities for biotechnology development, as well as protocols and regulatory procedures related to biosafety and biocontainment.

In infrastructure support and development, construction of a level-2 biosafety greenhouse complex and head house is in progress. A contractor is being identified, and construction will commence in January. We expect the facility to be operational before mid-2003.

The open quarantine site (OQS) at Kiboko is now operational. This facility will be used to verify, under field conditions, the results obtained from bioassays carried out at the level-2 biosafety greenhouses. Meantime, mock trials will continue to be grown to calibrate the fields for growing maize and to train staff and collaborators on management of OQS facilities.

In a project where new technology is being developed and disseminated, communication is important for education and creating public awareness. Considerable effort has been given to creating dialogue and raising public awareness about Bt and insect resistant maize and biotechnology in general. Communication has been emphasized through stakeholders meetings, such as this one, positive media relations, creation of print and electronic materials, working closely with local press to achieve objective coverage, and participation and documentation of IRMA-related seminars and conferences.

This year, emphasis was given to reaching extension agents to enhance their understanding of the technology and the issues associated with it. Seminars were held for lead extension staff of the Kenyan Ministry of Agriculture and Rural Development in the major maize growing regions of Kenya. Approximately 120 resource persons and extension personnel attended with presentations by KARI and CIMMYT scientists. The objectives of the seminars were to inform extension staff about Bt technology and the IRMA project and discover what information gaps the project needs to address that we may not have previously considered, identify especially good communicators among extension staff, and particularly effective messages, for possible later use in video and/or radio productions (low-cost, straightforward productions for direct use with farmers), and refine a series of fact sheets on Bt maize through extension's feedback and suggestions. Two rough-cut videos have been made: one is of the presentations by the resource persons and the other is of the extension officers giving presentations on aspects of the technologies (Star Search exercise).

Seminars were presented to a cross section of the public including policy makers, journalists, NGO fora, and scientific meetings and to stakeholders like you.
We are confident that these activities will ensure that the intended purpose of the IRMA project—putting improved maize varieties with insect resistance into the hands of the farmer—is acheived.

I will not tire to stress that great attention is being paid to following the prescribed biosafety regulations and protocols and giving our staff the levels of training needed to conscientiously and effectively carry out these measures. At all stages of the project, we will evaluate the impacts of the improved maize on the environment and on farmers and consumers.

We hope that this project will serve the intended purpose as a positive example to other nations on how we can develop partnerships between projects and institutions in the region to safely and responsibly put this technology to work for the betterment of our people and our nations.

Thank you for your attention and I look forward to hearing your views and questions on this project.

Remarks by the Syngenta Foundation for Sustainable Agriculture

Dr. Andrew Bennett, Executive Director, Syngenta Foundation for Sustainable Agriculture.

Dr. Andrew Bennett, the Executive Director of the Syngenta Foundation for Sustainable Agriculture said he was still new in his post, but was very grateful to have been given the opportunity to attend the stakeholders meeting, which is an interface between public, private and civil society. He said none of the project's partners had all the resources and skills to address the major maize production problems in Kenya, and therefore such effective partnerships were required to achieve the project's aims. It is important that the world knows what Kenya wants in agriculture since agriculture provides food, goods, and services to the Kenyan population. He said the Syngenta Foundation is interested in giving people public goods and that it believes in giving people choices from which to choose. The executive director was very impressed with the IRMA project, as it is a classic example of good practice: trying to do things right by giving farmers choice and bringing together the private and public sector, unlike other projects in which research has gotten detached from its ultimate clients. The executive director said handling genetically modified organisms requires capacity building and that he is very happy to see that IRMA has trained most of the staff involved in the project, but he acknowledged that the project still needs to bring other people in to help enhance funding and acceptance of the technology.

Dr. Bennett said, the Syngenta Foundation was keen to remain engaged to the project till the end, he therefore requested the stakeholders to advise the scientists involved in the Bt technology in areas where they may be going wrong because the technology is being developed for the communities in Kenya. The scientists should learn from mistakes they have done in the past and improve on areas that may need more research. Dr. Bennett concluded his speech by saying that agricultural policies are changing and are becoming more conducive for African countries, therefore African countries should get access to technologies and increase their markets. He advised the IRMA project to make the technology more acceptable to farmers to give farmers an opportunity to change their lives, the Foundation will be happy to be associated with the generation of technologies, which will improve the livelihood of the Kenyan people.

Remarks by CIMMYT

Dr. Masa Iwanaga, Director General, CIMMYT.

Dr. Joseph Wanjama, Director of Agriculture and Livestock Development,
Dr. John Kedera, Director, Kenya Plant Health Inspectorate Service (KEPHIS),
Dr. Andrew Bennett, Executive Director, Syngenta Foundation for Sustainable Agriculture,
Dr. Stephen Mugo, Coordinator IRMA Project,
Distinguished IRMA stakeholders, KARI and CIMMYT scientists,

It gives me great pleasure to travel to Kenya once again and meet with all of you here at the IRMA Stakeholders Meeting. I had the opportunity to come to your beautiful country while working as Deputy Director General of the International Plant Genetic Resources Institute (IPGRI). But now, as the new Director General of CIMMYT, I am wearing a much different hat on this trip. I must say that I am enjoying my new role and the opportunity to meet with Kenyan scientists working on the front lines of achieving food security for the nation.

Now, CIMMYT's specific involvement in IRMA Project. CIMMYT welcomes the opportunity to work side by side with your scientists and organizations like KARI, the Ministry of Agriculture and Rural Development, and KEPHIS to reach food security and improve the lives of farmers and the resource poor. And I must say that having the support of the Syngenta Foundation for Sustainable Agriculture—not just for funding, but in their strong commitment to our common goal, and knowledge about agricultural development—is a tremendous advantage. From the beginning we've seen this project as a partnership of KARI, CIMMYT, and the Syngenta Foundation, and this relationship has grown even stronger over the years. This is a good thing because the further we progress in the IRMA project, the clearer it becomes that no single institute could accomplish our goal alone.

As we've just heard from Dr. Mugo, the IRMA project is making steady progress towards its goal of developing and deploying insect resistant maize. As we know, insects destroy a large portion of maize crops in Africa. And, as we see in the countries of southern Africa, this is maize we cannot afford to lose if we want to prevent famine and fight hunger. CIMMYT believes sub-

Saharan Africa is a key battleground in this fight, and Kenya is a leader in taking on this challenge. But it is a fight we cannot win with fine words or good thoughts. We need to use other resources.

First, we need to use our intelligence and ingenuity to develop new tools, like insect resistant maize. Second, we need determination and patience, to continue this work when all does not go smoothly. Third, we need heart, so we never forget that this is not an abstract exercise, but a genuine effort to free people from the cries and pain of hunger. And finally, we need you, the stakeholders, to give us the input that keeps us on track. Together, we can develop and deploy maize that will give 15 or 20% more yield. But as I've already said, we cannot do it alone.

The IRMA project may develop some interesting maize varieties . . . but if the farmers don't adopt them, they are of little use. We may develop genetically modified maize that frees farmers of the work and hazards associated with pesticides . . . but if questions and suspicions remain, they may be of little use. We may also develop strategies to make sure that the insect resistant maize we produce maintains its resistance . . . but if those approaches are not practical and are not implemented by the farmers, they are of little use.

So today we are meeting with you—the stakeholders—to make sure that what we are developing will be used by farmers and consumers. We are looking for your input to help us keep our commitment to the farmers and consumers of Kenya. And we believe that you, and KARI, and Kenya can serve as a model for the rest of sub-Saharan Africa, on how new technologies can be carefully and thoughtfully developed and evaluated, and harnessed to make a better tomorrow for the continent and its people.

Thank you and I look forward to hearing from many of you in the question and answer session.

Remarks by Director, Kenya Agricultural Research Institute (KARI)

(Read by Dr. Joseph Ochieng, Assistant Director for Food Crops)

Dr. J. Ochieng, Assistant Director, KARI, represented the Director of KARI, who was unable to attend the meeting because of other commitments but who sent his apologies. In his remarks, Dr. Ochieng recognized the presence of Dr. Masa Iwanaga, Director General of CIMMYT and Dr. Andrew Bennett, Executive Director of the Syngenta Foundation for Sustainable Agriculture. He said that the Director of KARI was very proud to be associated with the IRMA project, whose major goal was to transform the economy of the Kenyan farmers by making a difference in food production and security by reducing yield losses in maize due to stem borers. The project has gone through many phases and has involved many participants, and collaborating institutions, policymakers, and stakeholders have been kept well informed about the project's progress through workshops, stakeholders meetings, and steering committee meetings. He said the Director of KARI was very interested in seeing the project achieve its goals in Kenya and extended to other parts of Africa. He encouraged the participants to ask any questions they might have about the Bt technology.

Question and Answer Session

Questioner: Mr. Drecky E. Okeno (farmer, Western Kenya)
International laws on biological materials may change. The IRMA project is a joint venture between KARI and CIMMYT. What precautions are there to safeguard against any possible legal issues regarding intellectual property rights that may delay or hinder deployment of Bt maize seed supply?

Respondent: Dr. S. Mugo
The ownership of the technology will belong to the collaborating institutions, both KARI and CIMMYT. Last year the IRMA project commissioed an intellectual property rights (IPR) review by Swift-Cornell and the results were that IPR issues will be relatively uncomplicated.

Questioner: Dr. Danny Romney (ILRI)
i) Has the feed value of stover/thinning, etc., for ruminants been considered? ii) What are the potential trade-offs between supplying forage for animals and use as refugia for the fodder; are there any positive effects in encouraging farmers to plant more fodder?

Respondent: Dr. S. Mugo and Dr. M. Iwanaga
i) Research on feed value has already been done by other scientists on most of the Bt genes in maize. It is unlikely that addition of a Bt gene would change the feed value of the new variety from that of the untransformed version of a maize genotype. However, resistance to stem borers through conventional breeding methods may often involve leaf toughness occasioned by thick or tough epidermis. This may or may not affect feed value as the bulk of feed is from the stalks that may or may not change. This could be a subject of research between the IRMA project and an institution like ILRI.

ii) Refugia are good news for livestock farmers because it will increase the area under livestock feed. Some of the refugia species such as sorghum can be used for food as well.

Questioner: Mr. Arthur Wanyoike (farmer, Nakuru)
Maize yields in Nakuru districts are very low. What is the progress in developing new early maturing maize varieties for the high altitude areas of Nakuru as promised last year?

Respondents: Dr. S. Mugo, Dr. G. Ombakho, and Dr. J. Kedera
Low yields may be caused by several factors like drought and low soil fertility. Farmers should take their soils for analysis so as to get proper recommendations on fertilizer use. The PDALE Rift Valley, Mr. Koech, asked Mr. Wanyoike to visit his office in Nakuru to get more advice on suitable maize varieties. Breeding maize for the high altitude areas is coordinated at Kitale, and the maize breeder from KARI Kitale knows the problems in the cool high altitude areas. Intermediate to extra early maize germplasm has been identified and are being used to improve on maturity and for disease responses.

Questioner: Mr. Peter E. Kataka (farmer, Kakamega)
i) Farmers concerns on Bt maize are possibilities of physiological disorders on maize plants and different taste as food. Will the Bt maize be safe for human consumption?
ii) Is there a possibility of combining resistances to stem borers, foliar diseases, the parasitic *Striga* weed, and tolerances to drought and low nitrogen into a single maize variety so as to reach farmers as a package?

Respondent: Dr. S. Mugo
i) Research done on food safety shows that Bt maize is safe for human and other mammals. The human stomach has higher acidity compared to that of an insect that is primarily basic; Bt crystal endotoxins require an alkaline medium to be active. Crystal proteins need to have suitable receptor cells to attach to in order to be effective. Humans and other mammals do not have receptor cells for the endotoxins. These receptor cells are highly specific to the crystal proteins. This specificity is seen even among different species of stem borers. Hence crystal proteins are digested and broken down to constituent amino acids. This makes it difficult even to study long-term effects of Bt crystal proteins in humans and livestock. The Bt maize to be deployed will be the same maize varieties currently being used by farmers, the only difference will be the addition of the *Bt* gene. The physiology, appearance, taste, and other qualities will be like the maize varieties that farmers are growing. World bodies like FAO and WHO, and national agencies in the United States such as the USDA, FDA, and EPA have put out considerable information on safety of Bt maize. These organizations indicate that Bt is safe based on the science.

ii) It is possible to combine genes for tolerance to various stresses in one variety. The *Bt* gene will be incorporated into varieties with resistance to the stresses you mentioned in a way that will ensure that we combine good traits with insect resistance.

Questioner: Mr. Alexander Keino (farmer, Trans-Nzoia)
What is the project doing to address the issue of larger grain borer damage of maize? Most farmers in Trans-Nzoia stoke maize for weeks to dry before harvesting, and as a result the maize gets infested by weevils and larger grain borers while still in the field.


Dr. G. Ombakho, Maize Breeder at KARI Kitale responds to a stakeholder's question

Respondent: Dr. S. Mugo
The IRMA project has included screening for resistance to storage pests, starting with weevils (*Sitophillus zeamais*). All genotypes being improved for resistance to stem borers are screened to ensure that we retain only those that have resistance to weevils. This is considered a value-added activity. We have now added germplasm improved for resistance to weevils from CIMMYT-Zimbabwe. The entomologists have also developed a methodology to screen maize for resistance to the larger grain borer and this will be done routinely on all maize germplasm under improvement for resistance to stem borers.

Questioner: Dr. Sabina Wangia (Lecturer, Egerton University)
Most farmers are resource poor and would prefer low inputs strategies in maize production. Will the Bt maize cost less or more than the open pollinated varieties being used by the farmers currently?

Respondent: Dr. S. Mugo
Bt maize seed may be more costly than its non-Bt equivalent. However, the farmers will save money by foregoing the need to purchase pesticides for stem borer control. The other management practices, e.g., weeding and fertilizer use will be similar to the current recommendations given by KARI and the Ministry of Agriculture.

Questioner: Mr. Henry Wahinya (journalist, The People Daily)
The majority of farmers are small scale and do not practice monoculture. What impact might Bt maize varieties have on other complementary crops grown on the farm if insects are deterred from their natural feeds.

Respondent: Dr. S. Mugo
Maize does not have any wild relatives in Kenya, therefore there will be no cross pollination with other crops or wild plants. Most crop species with maize are legumes such as beans and cowpeas, which are not usually damaged by stem borers. Cereal intercrops like sorghums and millets and fodder species like napiers would even be considered a blessing because they provide refugia for the Bt maize.

Questioner: Prof. Samuel Gudu (Lecturer, Moi University)
Which maize varieties are your first targets for incorporation of Bt resistance? Do you target hybrids, OPVs, or landraces?

Respondent: Dr. S. Mugo and Dr. J. Wanjama
The Bt technology is targeting both small- and large-scale farmers. Hybrid Bt would be the easiest for seed companies and for stewardship of the technology. However, Kenyan society has a place for OPVs. Small-scale farmers grow hybrids as a well as OPVs, while large-scale farmers mainly grow hybrids. Three-way cross hybrids are more sustainable than single-cross ones. Open pollinated varieties will be made, but will require farmer training on seed selection and management of Bt maize. As we intend to put Bt in improved genetic backgrounds, Bt will not be added to landraces per se. It is recognized that some of the OPVs trace their origin from elite landraces. The IRMA maize cannot be targeted just to small-scale or large-scale producers. Some technologies are scale neutral. Crop varieties are scale neutral.

Questioner: Prof. S. Mbogoh (Lecturer, University of Nairobi)
Could the insects that survive chewing on the Bt maize wipe out non-Bt maize in Kenya?

Respondent: Dr. S. Mugo
The refugia is a safety net in the neighborhood of Bt maize where the susceptible insects will survive and mate with any resistant ones coming from the Bt maize. This reduces the chances of having homozygous resistant stem borers. This is why insect resistance management is important in the IRMA project. A survey was conducted in various maize growing environments in Kenya to discover whether natural refugia already exist or if there will be need to introduce a stratified refugia with the help of the extension staff. On-station trials to identify the best refugia species have also been carried out.

Questioner: Mr. Francis Ndambuki (Research Manager, Kenya Seed Co.)
How long would it take and at what cost to convert a maize line to Bt?

Respondent: Dr. D. Hoisington
There are various issues of biosafety and training from evaluation of the technology to the time it will reach farmers. The project is still looking at different *Bt* genes to identify those that will be effective against *Busseola fusca.* Once the most effective *Bt* genes are found for all the major stem borers, which we hope will be soon, the conversion process does not take long. The costs will be established then.

Questioner: Ms. Annah Njui (World Agroforestry Center [ICRAF])
The issue today is "demand-driven technology." Does the IRMA project have a deliberate mechanism to sensitize the small-scale farmers to this new technology so that there is demand for this very attractive technology, bearing in mind that product dissemination is one of the objectives?

Respondent: Dr. S. Mugo
KARI and CIMMYT have taken communication and documentation very seriously in our partnership by being open and transparent. There are very good avenues to reach farmers through the existing extension channels. The communication group has set up a target to reach 3,000 extension officers by the end of 2003, who will in turn sensitize the farmers.

Questioner: Prof. Julius Nyabundi (Maseno University)
i) Given the mobility of the maize grain in Kenya and the indiscriminate use of grain as food, how effective is the use of refugia as a mechanism for controlling spread of resistant pests?
ii) Given the concerns raised in my question (i, above), should we think about using terminator genes as a precaution to protect the environment.

Respondent: Dr. J. Wanjama, Dr. S. Mugo, and Dr. J. Songa
Once the variety has been released there is no more control of where it will be grown. The farmers have the final word on what they grow. Therefore scientists cannot dictate where a variety will be grown—they can only recommend. Some technologies are specific while others are scale neutral. Therefore, it is wrong for us to create on impression that once we give you the insect resistant maize then we have solved your problem. Most farmers get seed from their neighbors. Biological processes are dynamic. Therefore the varieties that may come from this program will not last forever in the market. Resistance can break down. Therefore breeding for insect resistance will have to be a continuous program. For example, the wheat breeders have screened more than 200 wheat varieties for resistance to pests in order to have other sources of resistance.

We need to be aware that there is no perfect technology and that it is not possible to completely control farmers growing grain such as maize. In the IRMA project we have ensured that there are concerted efforts to develop effective resistance management strategies, which will be used by farmers (that purposefully plant the Bt maize) to reduce the rate of evolution of resistance to the Bt maize.

Questioner: Dr. Alice W. Kamau (Crop Management and Research Training)
Is the effectiveness of the *Bt* genes related to the size of the pest as research shows that they are more effective on *Chilo spp.* and *Sesamia calamistis*, which are smaller than *Busseola Fusca.*

Respondent: Dr. S. Mugo
Specificity of Bt is a single dominant gene, which you can potentially put in any genetic background. There are many types (strains) of Bt, most of which are type 1. Every type is specific to a particular genera; the stem borer strain of Bt is specific to lepidoptera, and it is because of the specificity, that those that kill *Chilo partellus* are not killing the *Busseola fusca*. The binding of each Bt toxin is specific to specific receptor cells. You may get some Bt toxins, that can kill several genera. From this, specificity is not related to the size but to the biology of the stem borer species.

Questioner: Dr. Esther Magiri (Lecturer, Jomo Kenyatta University)
i) Will facilities for transformation with Bt genes be set up in Kenya instead of transformation being done in Mexico?
ii) Has the (gene) cleaning process been done on Bt maize in Mexico to remove antibiotic resistance and other sequences? If yes, how?

Respondent: Dr. S. Mugo and Dr. D. Hoisington
i) The project started by using *Bt* genes and products that are available in Mexico and training personnel on genetic engineering and biosafety issues in the management of Bt materials. After training and setting up biosafety laboratories, greenhouses, and a quarantine field, as required by the biosafety regulations in Kenya, the backcrossing will be done in Kenya after obtaining import permits. Facilities are being set up for transformation in Kenya.

ii) The cleaning process has been done. The first generation events had selectable markers. The second generation "clean events" have only the gene of interest. The selectable marker has been removed by co-transformation, whereby the selectable marker is segregated out after transformation.

Comment: Mr. Alexander Keino (farmer, Trans-Nzoia)
Researchers should address or develop effective strategies to address the issue of poor soils of Cherangany division of Trans-Nzoia.

Respondent: Dr. J. Kedera
The farmers should take their soils for laboratory analysis to find out the soil fertility status and the appropriate fertilizers to use. Farmers often use DAP for planting and top dress with urea. This increases soil acidity that makes phosphates unavailable to the plant.

Comments: Mr. Paul Okong'o (Chairman TATRO group, a CBO in Western Kenya)
Farmers who have been attending these IRMA stakeholders meetings for the last three years are very appreciative because of (i) the involvement of farmers from the beginning, and (ii) the opportunity for information dissemination to other farmers. Patience is needed for researchers to come up with proper outputs. Through stakeholders meetings, farmers have been following the whole process of the development of Bt maize technology and they understand the problems that scientist are facing, e.g., the fact that they need more time for research.

Comment: Mr. Edward Nguta Munyao (farmer, Machakos)
The time when the farmers got everything from scientists has gone. So when the Bt maize becomes available, the farmers should own the technology for sustainability.

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22 November 2002

Insect Resistant Maize for Africa Project Holds Third Stakeholders Meeting

Nairobi—The Insect Resistant Maize for Africa (IRMA) project held its third Stakeholders Meeting on Friday, 22 November at the Hilton Hotel, Nairobi. More than 150 stakeholders and project team members were invited to the meeting, which was held to provide updates on the project's progress, respond to questions about the project and its technologies, and to solicit input on key issues related to the development of insect resistant maize and farming practices associated with it.

Stakeholders from farmer and environmental groups, religious and women's organizations, NGOs, Kenyan universities, international agricultural centers, an organic farming institute, KEPHIS, the Ministry of Agriculture and Rural Development, KARI, the International Maize and Wheat Improvement Center (CIMMYT), the Syngenta Foundation for Sustainable Agriculture, various other foundations, and the news media were invited to attend.

Dr. Ephraim Mukisira, Deputy Director of KARI. Made welcoming remarks, Dr. Joseph Wanjama, Director of Agriculture, MOARD, officially opened the meeting. Dr. Stephen Mugo, IRMA project coordinator provided participants with an update on project activities. Remarks to the assembly were made Dr. Andrew Bennett, Executive Director of the Syngenta Foundation for Sustainable Agriculture, Dr. Masa Iwanaga, Director General of CIMMYT, and Dr. Romano Kiome, Director of KARI, on behalf of their respective organizations. Dr. John Kedera, Managing Director, Kenya Plant Health Inspectorate Service (KEPHIS) chaired the meeting.

The IRMA project, initiated in 1999 by KARI, CIMMYT, and the Syngenta Foundation, aims to increase food security and improve the livelihoods of smallholder farmers in Kenya and sub-Saharan Africa through the development of maize that is resistant to stem (stalk) borers. In a typical year, stem borers destroy about 15% of the maize crop in Kenya, with a value of approximately US$ 72 million. At the individual farmer level, a severe stem borer infestation can result in a devastating total crop loss.

To develop maize varieties that resist these destructive pests, the IRMA project uses conventional crop breeding and genetic engineering techniques. Given the controversy that surrounds genetically modified (GM) maize, the project leadership has given the highest priority to informing stakeholders about the technology and responding to their concerns. Considerable effort has also gone into helping Kenya develop the expertise and facilities needed to safely deploy and monitor GM maize as part of an overall strategy for controlling the stem borers. Testing facilities developed by the project include a biocontainment laboratory at the National Agricultural Research Laboratory (NARL), an open quarantine site, and a planned level II biosafety greenhouse, the first facility of its kind in Eastern Africa.

"The project has taken some significant strides since we last convened the group", says IRMA project coordinator Stephen Mugo, "chief among them are the training of more than 20 KARI, KEPHIS, and CIMMYT-Kenya scientists and technicians on genetic engineering, management of biosafety facilities, and other techniques and the near arrival of conventionally developed insect resistant maize varieties. Our socioeconomic component have completed a number of on-farm baseline surveys, which give us a much better understanding of the farming systems in key maize producing regions. We have acquired and developed Bt proteins, that both singly and in combinations with one another may be more effective against Kenyan stem borers. And in the key area of controlling the emergence of insects that are resistant to Bt maize, we have conducted surveys of potential wild and cultivated host species to maintain susceptible insect populations. The results from the coastal Kenya are particularly encouraging, showing that 20-30% of the needed refugia could be found in existing stands of wild and cultivated species.

"We've looked forward to presenting these activities and results to our stakeholders and hearing their insightful and useful questions and comments. And once again they did not disappoint us. These sessions keep us attuned to the diverse perspectives of the wider community and are a potent tool in helping us guide the project in a fruitful and responsive manner".

List of Packet and Background Materials

1. CIMMYT and KARI, 2002. Insect Resistant Maize for Africa Project, An outstanding Partnership: CIMMYT
2. CIMMYT and KARI, 2002. IRMA Updates Vol. 3, Issue 1 + 2, August 2002. CIMMYT, Mexico.
3. CIMMYT and KARI, 2002. IRMA Updates Vol. 3, Issue 3, September 2002. CIMMYT, Mexico.
4. WHO 20 Questions on Genetically Modified (GM) Foods: WHO
5. Crop Biotech Update 15, November 2002. GM Safe for farm Livestock, State to buy maize from Uganda.
6. Mugo, S.N., D. Poland, J. Songa, H. De Groote, and D. Hoisington (eds.0 2002. *Second Stakeholders Meeting: Insect Resistant Maize for Africa (IRMA) Project.* IRMA Project Document No. 7. Nairobi, Kenya: KARI and CIMMYT.
7. CIMMYT Applied Biotechnology Center
8. CIMMYT Economic Program
9. CIMMYT Maize Program
10. CIMMYT Today
11. Opening Speech by Dr. J. K. Wanjama during the Third Stakeholders' Meetings (1822 November, Nairobi, Kenya). This volume.

List of Invited Stakeholders for the Insect Resistance Maize for Africa

(IRMA) Project Third Stakeholders Meeting (22 November 2002)

KARI scientists
CIMMYT scientists
Government of Kenya Ministries (Director of Agriculture, Ministry of Agriculture and Rural Development, Dept of Resource Survey and remote sensing, Ministry of Energy, NCST, National Environments Secretariat)
Directors of NGOs (Green peace and Greenbelt movement, Action Aid/AWC, Biosystems Resource management, Broad base Promotions, Agro-business consultants, CARE Kenya, and CRS)
Chairman, Kenya Agricultural Biotechnology Platform
Chairman Kenya National Union of Farmers
Chairman KARI Biosafety Committee
Chairman, National Biosafety Committee
Director, KEPHIS
Director, Kenya Industrial Property Office (KIPO)
Managing directors of seed companies dealing with maize in Kenya (Kenya Seed Company, Western seed Company, Monsanto, Aventis Crop Sciences)
Biotechnology Trust Africa (BTA)
Churches (two representatives involved in agricultural projects)
Managing Director, Kenya National Farmers Union
Farmers and farmer groups (Bahati Environment Farmers Group, Tatro Central Farmers Group)
Farmers' cooperatives (two representatives)
Journalists (Nation newspapers, The Standard, The People, Times newspapers, African Sciences, Business Times, Women and Children Services, AFAJ, Central Africa News Agency, Insight Media consultants, Inter-press Service, Maoni network (The Scholar), PICASSO Productions, Interlink Rural Information Service, Biosafety News, Topic Africa magazine, AWC-Features, De Morgen Newsletter)
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Director General, ICIPE
Director, UNEP
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