1. Research Activities (April 2011-March 2012)

1.1 Outlines of Research Activities

(1) The Center

Arid Land Research Center (ALRC) is an independent department of Tottori University and at the same time is a National Joint-use Research Facility. The mission of the ALRC is to conduct research on desertification and to develop sustainable agricultural practices in arid and semi-arid areas. The door is open to all teachers of universities who are engaged in this field of study.

Tottori University conducted a Global Center of Excellent for Dryland Science" as a Global COE program funded by the Ministry of Education, Culture, Sports, Science and Technology from FY 2007 to FY 2012, of which the leading department was Arid Land Research Center. This GCOE program established a center for education and research in the field of dryland science through developing various initiatives by putting the following three goals as main pillars of the program, 1) Fostering the talents who work globally, 2) Promotion of world-class research activities, 3) Establishment of academic research network. Achievement of this objective formed the foundation of designing our national arid land science as a worldwide top-level program in this field. Consequently this will contribute to increasingly technological support of Japan as a UNCCD ratification country.

We are conducting Institutional Program for Young Researcher Overseas Visits, which is being funded by JSPS, in FY 2010. This 3 year program aims for talented young researchers to learn and foster their experiences through overseas visits to research institutions world-wide.

We have started a new 5 year project funded by the Ministry of Education, Culture, Sports, Science and Technology; Project Asian Dust "Assessment and Control of Dust emission in Degraded Drylands of East Asia" in FY 2011. The goal of this project is to assess the dust effects on human health and environments, to elucidate the dust emission and sandstorm mechanisms, and to develop mitigation techniques. The goal of this project is to assess the dust effects on human health and environments, to elucidate the dust emission and sandstorm mechanisms, and to develop mitigation techniques. The expected achievements of this program are; to clarify the sandstorm and dust emission mechanisms in the dryland of Mongolia and China, study the effects of dust on human health, human activity and ecosystems in the source drylands and Japan, conduct research to develop effective measures to control sandstorm and dust emission in source areas.

Guest house has been built in August 2011, where collaborative researchers and students stay for their experiments using our research facilities. This facility has 2 twin rooms, 4 single rooms and 1 training room. It has been inconvenient for the visitors to reach our Center since the location of our Center is away from the center of the city. It would be appreciated if many visitors would enjoy our new Guest House

Organization, Management, and Funding Subsidies

ALRC is managed by the Director, a Conference composed of professors and associate professors, a Board of Management composed of members from outside as well as professors of ALRC, the five research divisions, the office section and the technical section. In practice the Conference and the Board of Management operate our Center.

Member of the Board of Management	
Affiliation	Name

Professor, Arid Land Research Center	Masato SHINODA
Professor, Arid Land Research Center	Hisashi TSUJIMOTO
Professor, Arid Land Research Center	Mitsuhiro INOUE
Professor, Arid Land Research Center	Norikazu YAMANAKA
Dean, Graduate School of Engineering, Faculty of Engineering	Hisataka TANAKA
Dean, Faculty of Agriculture	Yoshinobu KITAMURA
Dean, United Graduate School of Agricultural Science	Nitaro MAEKAWA
Director, Center for International Affairs	Ryoji WAKA
Professor, The Open University of Japan	Motoyuki SUZUKI
Professor, Tokyo University of Agriculture, Research Institute	Eitaro MIWA
Professor, Tokyo University	Shigenori MORITA
Tokyo University of Foreign Studies	Michio KANDA

The five divisions are:

1) Climatology and Water Resources
2) Biological Production
3) Afforestation and Land Conservation
4) Socioeconomics
5) Health and Medicine

The full-time divisions from 1) to 4) have five professors, six associate professors and three assistant professors. The other division has one associate professor. The all division has three visiting professors from Japan and three visiting researchers from abroad. In addition, 8 project researchers are stationed at ALRC. Thirteen office staff (seven clerks and six associate clerks), four technical officers and three assistant technicians support the research and education.

Joint-Use Research, Education, Publication

During the fiscal year of 2011, 68 Joint-Use Researchers (Teachers from national and private universities) were attached to the Center. The number of students as of October 2011 is 28 (14 Ph.D. Students, 8 Master Students, 5 Undergraduate Students, 1 Research Student).

Seminars were often held by a large number of internal and external experts. The foreign visiting researchers periodically give seminars.

Annual report has been published since the establishment of ALRC, which provides a brief overview of the activities in its various divisions and also summarizes our research and education.

The seminar of Joint Research was held on December 3, 4, 2011 at Arid Land Research Center, Tottori University.

(2) Research Divisions

1) Climatology and Water Resources Division

Masato Shinoda (Prof., Climatology)

The Climatological Subdivision conducts research on eco-climate system dynamics in arid region;

interaction between the large-scale climate and terrestrial ecosystems (including agricultural ecosystems) through water, energy, and carbon circulation. Focus is placed on climate change analysis in arid region, drought sciences, and early warning system of meteorological disasters. We also promote research on dust emission processes in Mongolia that are linked to the arrival of aeolian dust to Japan. Major study topics are as follows:

(1) Drought experiment in a Mongolian grassland (Grants-in-Aid for Scientific Research from the Japanese Ministry of Education, Culture, Sports, Science & Technology: MEXT).
(2) Climate memory dynamics of terrestrial ecosystems over the Asian-African arid region (Grants-in-Aid for Scientific Research from MEXT).
(3) Developing an early warning system of drought and dzud in Mongolia (JICA project).
(4) Developing a biogeophysical model simulating the dust emission processes (the Global Center of Excellence program for dryland science of Tottori University).

Reiji Kimura (Assoc. Prof., Meteorology)

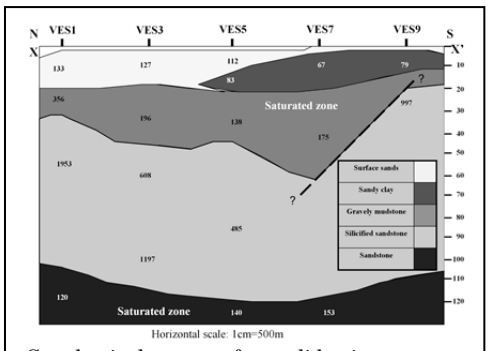
The Meteorology Subdivision conducts research mainly as follows:

(1) Quantitative analysis of heat fluxes in arid land.
(2) Monitoring and modeling of surface moisture by combining the meteorological and remote sensing data.
(3) To make clear the physical mechanism for preventing the dust outbreak by vegetation in northeast Asia.

These studies are conducted under the aid by Japan Society of the Promotion of Science Grants (KAKENHI 20405038, 21404007, and 20255001), MEXT Project of Integrated Research (Asian Dust Project), and JAXA Global Observation Mission, especially in China and Mongolia.

Hiroshi Yasuda (Assoc. Prof., Hydrology)

The Subdivision of Hydrology has researched on water circulation in arid land. Last year, the focusing has stepped from Chinese Loess Plateau to Sudan and studied on 1) characteristics of water uptake from groundwater by alien vegetation, mesquite; 2) water budget of wadi (ephemeral stream); 3) analysis of precipitation time series. In Sudan, research activity such as geophysical survey and boring was performed at a wadi basin under a project by Japan Society of the Promotion of Science Grants-in-Aid for Scientific Research (B), 2011-2015, 'Relationship between the exclusive invasion of alien vegetation, mesquite and heterogeneity of sub-surface zone in arid environment' (Project Leader: H. Yasuda). There is a high moisture zone at 20 – 50 m depth in addition to the Nubia Aquifer at 100 m depth. Groundwater level beneath a mesquite bush was observed and the water uptake property was considered. And seasonal and periodical characteristics of 11 rainfall stations over Sudan were clarified. Two visits were paid to Department of Water Resources Engineering, Lund Institute of Technology, Sweden, and developed a study on transportation in heterogeneous soil in arid land. This time, analysis on results of field experiments performed in Egypt and Tunisia were tackled.



Geophysical survey of a wadi basin.
The Nubia aquifer at 100 m depth. High water content zone at 20 - 50 m depth.

2) Biological Production Division

Hisashi Tsujimoto (Prof., Molecular Breeding)

The aim of Molecular Breeding Subdivision is to develop crop varieties with stable productivity by genetic and chromosome engineering. In fiscal 2011 year we conducted following researches:

- Molecular analysis of the genetic diversity of a wheat-related wild species, *Aegilops tauschii*, by using large-scale markers.
- Evaluation of drought tolerance in synthetic wheat lines that were produced by crosses between Aegilops tauschii and durum wheat.
- Evaluation of Fe and Zn contents in flours of wheat with alien chromosomes.
- Development of a chromosome engineering technique to introduce genes of wild species to the genome of wheat.
- Germplasm expedition of wheat and its relatives in Kazakhstan.

Field investigation of wheat production in Sudan. Many of wheat researchers are graduates or were visiting professors of Tottori University.

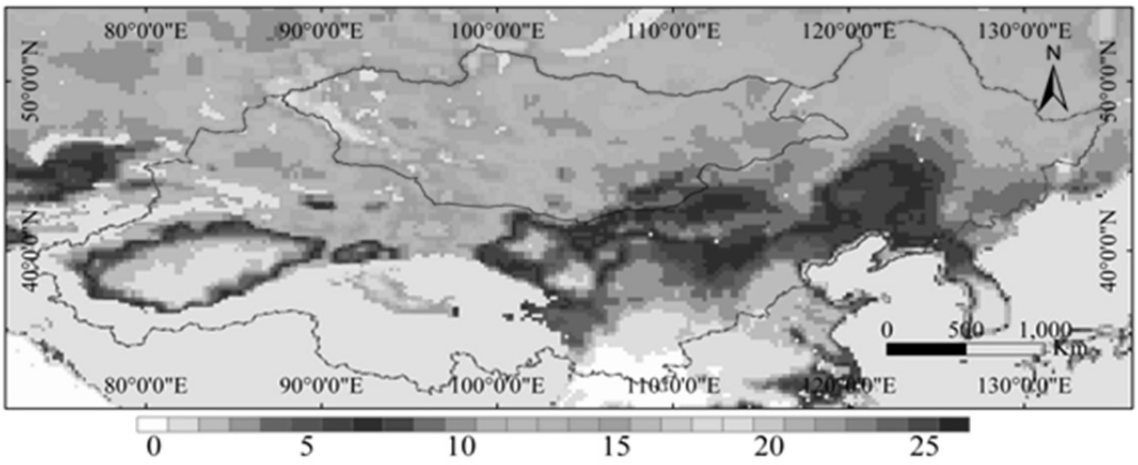
Investigation and experiment was carried out in Kazakhstan, Sudan, Mexico and China. Research activities were presented in the symposia and conferences held in USA, Germany, China and Turkey.

Atsushi Tsunekawa (Prof., Conservation Informatics)

The Conservation Informatics Subdivision conducts research on the monitoring and modeling of the plant production and ecosystem change in the dry lands. Particular efforts are being made to clarify the interaction between the atmosphere and the land surface (vegetation and soil) through water and dust, and to develop methodologies for evaluating the sustainability of ecosystems and local communities in dry lands. The research of the Subdivision is driven by combining the use of information technologies such as numerical modeling, remote sensing and geographic information systems (GIS); field observations; and experiments using ALRC's facilities. The main research topics in the fiscal year 2011 were as follows:

- Research on the photosynthesis and water use efficiency of *Jatropha curcas*.
- Research on remote sensing of near-surface soil freeze/thaw event.
- Research on the Grain for Green Program in Loess Plateau, China.

Overseas research activities during the fiscal year 2011 include visits to Central Rift Valley in Ethiopia for research guidance of Derege Meshesha at his research field from August 11 to 20, 2011. I participated in 'International Workshop on Dryland Science for Food Security and Natural Resources Management under Changing Climate' held at Konya, Turkey from December 5 to 11, 2011.



Mean spatial patterns (1998-2007) of near-surface soil thaw onset estimated using brightness temperature data of Special Sensor Microwave/Imager (SSM/I) sensor (Onboard of the United States Air Force Defense Meteorological Satellite Program (DMSP) Block 5D-2 satellites). The scale shows the weeks (0 to 52) of the year, and the gray means the filtered open water and high elevation regions.

Ping An (Assoc. Prof., Plant Eco-physiology)

The Plant Eco-physiology Subdivision conducts researches on the elucidation of eco-physiological characteristics of plants and crops and development of appropriate cultivation technology in arid lands. Particular efforts are being made to clarify the responses of plants and crops to environmental stresses and relevant mechanisms. The purpose of the studies is to develop cultivation technology for enhancement of water use efficiency and mitigation of drought and salinity stresses in dryland agriculture with combining the basic research in Japan using the ALRC's facilities and applied research at real fields in drylands. The current studies are:

- Salt tolerance and its mechanisms of soybean, tomato, and halophytes;
- Investigation of halophytes with high economic value in Bohai Bay in China and development of sea water irrigation system;
- Plant ecology in the desert of China.

Overseas research activities during the fiscal year 2011 include two times visits to China. One time was to visit Center for Agricultural Resources Research of the Institute of Genetics and Developmental Biology, Chinese Academy of Science, for the cooperative study on Halophytes Utilization in Bohai Bay in China. Another time was to visit conduct an investigation on underground saline water utilization and its market needs in China.

Mitsuru Tsubo (Assoc. Prof., Plant Production Science)

Research activities of the Plant Production Science Subsection are carried out in a wide range of fields such as crop ecophysiology, micrometeorology, ecoclimatology and agrometeorology. A research technique employed in the Subdivision is simulation modeling, and also field work and indoor experiment are conducted to build and test plant growth and production models. The main research topics are:

Typical grassland in South Africa
(Bloemfontein in March 2010)

- Plant response to drought.
- Modelling plant production in drylands.
- Development of a drought early warning system.

The major research activities during the fiscal year 2011 were summarized as follows:

- To develop a plant production model for semi-arid grassland of South Africa.
- To investigate relationships between vegetation and soil properties in Mongolia.

Takehiko Ito (Assist. Prof., Animal Ecology)

The Animal Ecology Subdivision conducts research on the ecology of wild animals and conservation of ecosystem and biodiversity in drylands. Main targets are ecological and conservational study on wild large herbivores, such as Asiatic wild ass and Mongolian gazelle, inhabiting central Asia. We use satellite tracking to describe their long distance movements, and combine the use of remote sensing, geographic information systems (GIS), and field observations to analyze factors of their habitat selection and movement, and influences of climate fluctuation and artificial constructions on them.

Vegetation survey in Mongolian

In the fiscal year 2011, we surveyed environmental factors such as vegetation in Mongolian Gobi, and analyzed relationships between movements of wild ungulates and environmental factors, especially the relationship between regional differences of vegetation factors and annual range size of Mongolian gazelles. We also studied on plant-animal interaction, mainly seed dispersal by large endangered mammals including the wild camel and Gobi bear, in Great Gobi A Strictly Protected Area in Mongolia.

Overseas research activities during the fiscal year 2011 include field researches and scientific exchanges in Mongolia, and attending conferences in New Zealand.

Amin E. Eltayeb Habora (Assist. Prof., Biotechnology Subdivision)

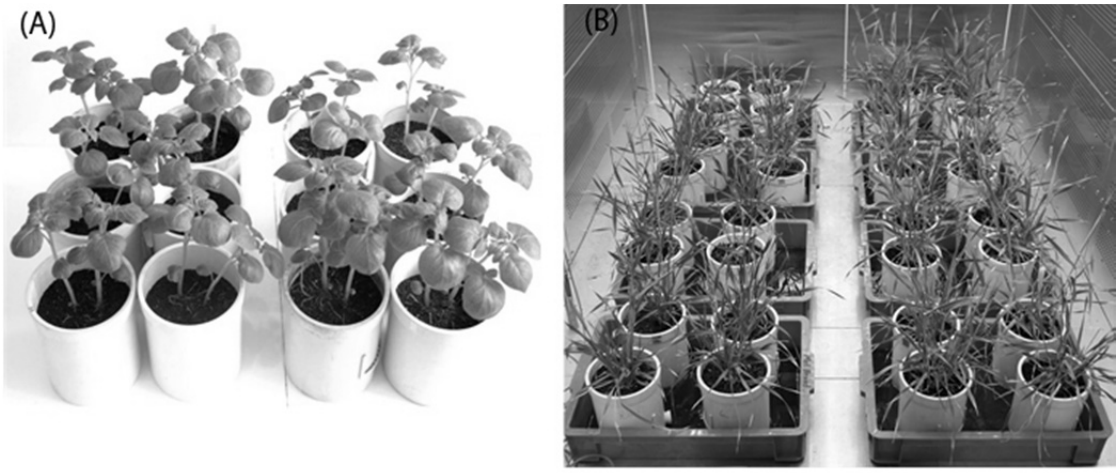
The Biotechnology Subdivision conducts research on plant genetics and plant molecular biology to enhance adaptation of agricultural crops to the dryland's stressful environments, and improve their tolerance to major abiotic stresses such as drought, salinity and heat. Aiming at identification of new strategies to assure yield stability and maximize land and water resources use efficiencies, the research of Biotechnology Subdivision uses advanced biotechnologies at the gene, protein, chromosome and genome levels to explore and identify plant genetic networks that control the physiological adaptation to drylands. The Subdivision adopts three main approaches:

I. Identification and isolation of novel genes for adaptation to dryland's environments, with particular emphasis devoted to discover novel genes for drought tolerance, water use efficiency and salt affected soils.
II. Production of stress-tolerant and highly adaptable genetically modified plants using gene recombination technologies and utilizing the center fully controlled and advanced facilities.
III. Evaluation of breeding materials derived from cultivated and wild relatives of crops.

The Subdivision is carrying research on important cultivated crops such as wheat (*Triticum aestivum*),

potato (*Solanum tuberosum*) and rice (*Oryza sativa*), and wild type plants such the Dune grass (*Leymus mollis*). The Subdivision has also contributed in supervising researches on evaluation of the tolerance of wheat-alien chromosome addition lines and wheat breeding materials to abiotic stresses such heat, drought, salinity and aluminum stresses.

Oversea activities during the fiscal year included participation on international workshops and conferences in Turkey, United states of America and Sudan.



A, Two types of transgenic potato engineered with higher contents of antioxidants; B, Genetically engineered wheat for increasing vitamin C contents. Plants were grown under controlled conditions.

3) Afforestation and Land Conservation Division

Mitsuhiro Inoue (Prof., Land Conservation)

Our central challenges are research on the reduction of soil degradation (soil erosion and salt accumulation), and on developing optimal soil and water management for sustainable agriculture in arid region. Particular efforts are being made to develop a proper technology for the land conservation to prevent soil degradation. I belong to crop production science group in the Global Center of Excellence program, and published 'Field Management for Sustainable Agriculture in Drylands' in English as the final report to present achieved goals of our five years project.

In the last fiscal year, my group had one doctoral student (Kingsley C. Uzoma) and two master's students under my direct supervision. I collaborated with twelve joint researchers in Japan, one research fellow supported by JSPS's Research Fellowship for Young Scientists (Ravolonantenaina, H. Andry) and an international collaboration researcher from Pakistan (Muhammad Irshad). In order to summarize my education and research life for 40 years, I gave final lecture titled 'Key word is water saving' on 31 March, 2012, and promoted search of Japanese word 'Kansouchitowa' using Google Search system. Recent main research topics were (1) Evaluation of salinity dependence effect on measurement of soil water content using dielectric moisture sensor, (2) Effect of soil amendments on crop production under saline water irrigation, (3) Water-saving vegetable cultivation using subsurface drip irrigation, (4) Development of labor-saving and water-saving irrigation using recycled products, (5) Determination of soil physical properties in arid regions.

Norikazu Yamanaka (Prof., Revegetation Science)

The Revegetation Science Subdivision conducts research on the revegetation in arid areas based on plant ecology. Main research topics of Revegetation Science Subdivision are as follows:

- Studies on the maintenance mechanisms of plant community in arid areas.
- Studies on the ecosystem restoration in arid areas.
- Studies on the drought and salt tolerance of trees and improvement of stress tolerance.
- Studies on the vegetation dynamics in coastal sand dunes.

Eco-physiological survey on *Populus simonii* planted in Kubuqi desert of Inner Mongolia, China

A new project "Assessment and Control of Dust Emission in Degraded Drylands of East Asia (Project Asian Dust)" started in fiscal year 2011. As part of this project, eco-physiological survey on plants growing in Kubuqi desert of Inner Mongolia was carried out in August 2011. Research on desertification and combatting desertification in Republic of Mali was also conducted in March 2012. In Aug. 2011, the collaborative research on biodiversity of grassland ecosystem in Mongolia was carried out with Mongolian State University of Agriculture. Collaborative research on Halophytes in Xinjiang province was carried out with Xinjiang Agricultural University in May 2011. Another collaborative research on Halophytes was also conducted in Ningxia province with Chinese academy of Science and Kyushu University in May.2011.

In Japan, study on the spatial distribution and seasonal change of nitrogen was carried out in the Tottori coastal sand dunes. Experiments on the salt tolerance of *Tamarix* species and the osmotic adjustment mechanisms of trees were conducted using facilities of the ALRC. Field survey on Osmoregulation of Mangrove trees was also conducted with Ryukyu University.

In Oct. 2011, I coordinated the Panel on 'Asian dust and desertification' as a side event of UNCCD COP10 held in Korea.

Research grants in the fiscal year include "Elucidation of osmo-regulation mechanisms and improvement of drought and salt tolerance of plants for revegetation in arid areas" by Japan Society of the Promotion of Science Grants-in-Aid for Scientific Research (B), 2009-2012 (Project Leader: N.Yamanaka).

Haruyuki Fujimaki (Assoc. Prof., Soil Conservation)

The subdivision of soil conservation studies on the prediction of salt accumulation and soil erosion and development of methods to prevent and remedy soil degradation in arid regions. Studies for water saving in irrigation and reuse of wastewater are also being carried out, since water is required for removing excess salts.

The main research activities in the fiscal year 2011 were as follows:

1) JST-JICA project (SATREPS), "Sustainable systems for food and bio-energy production with water-saving irrigation in the Egyptian Nile basin"
2) Determination of irrigation depths using a numerical model and quantitative weather forecast

Canola grown with drainage water in Egypt

Regarding JST-JICA project, i) large scale field experiment for

evaluation of water saving methods, ii)cropping experiment for production of biofuel using agricultural drainage water, iii) investigation for evaluation of tile drainage system, and iv) pot experiment for evaluating drought and salinity tolerance for biofuel crops (sunflower and castor bean) were mainly carried out.

I performed two field experiments in ALRC and Tunisia for the topic 2) above. A two-dimensional simulation model for determining irrigation depth of drip irrigation was developed and it was applied in the experiment in Tunisia.

Overseas research activities during the fiscal year 2011 were:

1) Visits to Egypt for "Sustainable systems for food and bio-energy production with water-saving irrigation in the Egyptian Nile basin" for 116 days in total 8 times.
2) visits to Tunisia to discuss research plan in the ITP program
3) oral presentation in ASA-CSSA-SSSA 2011 International Annual Meetings in USA

Takeshi Taniguchi (Assist. Prof., Microbial Ecology)

The Microbial Ecology Subdivision studies on the ecology and physiology of symbiotic microorganisms (mycorrhizal fungi, endophytic fungi, and endophytic bacteria) of plants living in dry lands.

Aims of the studies are to reveal the ecophysiological features of symbiotic microorganisms and to search for the useful microorganisms for ecosystem restoration. The main research topics in the fiscal year were as follows:

Automated mini-rhizotron set in semi-arid region in James Reserve, California, USA.

- How rapidly do the symbiotic microorganisms in roots respond to water inputs in a semi-arid region?
- Ectomycorrhizal community on *Quercus liatungensis* in Chinese Loess Plateau.

In studying these topics, sensor technique, automated mini-rhizotron, and molecular technique were used.

Overseas research activities during the fiscal year include the collaborative studies with Center for Conservation Biology, University of California Riverside in the U.S., and the Institute of Soil and Water Conservation (ISWC) of the Chinese Academy of Science (CAS) in China.

4) Division of Socioeconomics

Takayuki Ando (Assoc. Prof., Arid Land Development)

The Socioeconomics Division conducts studies on the sustainable rural development systems in arid lands using biofuel plants as part of the assessment of interrelation between livelihood and environment, and formulation, operation and evaluation of arid land development projects. *Jatropha curcas* L. has been focused principally as a biofuel feedstock because this plant is drought-resistant and it will be well adapted to the harsh environment of desert margins so it

photo1 public bus using bio-diesel

can be used to help to alleviate rural poverties and to improve their livelihood.

Main activities in the fiscal year 2011 were:

(1) Survey of current situation of *Jatropha* cultivation by independent farmers in Mexico.

In 2007, the Chiapas State Government made public the Bioenergy Programme of Chiapas; thereby multitiered support activities to the independent farmers were realized to produce bio-diesel for the public buses (photo 1). In fiscal 2011, economic evaluation on the *Jatropha* cultivation has been conducted in Tierra Santa village where the farmers are striving proactively in the municipality of Villa Corzo.

写真2 INIFAPとの協議

(2) The *Jatropha* Core Collection project.

In July 2010, the *Jatropha* Core Collection project started officially by signing the Agreement between INIFAP (National Institute for Investigation in Forestry, Agriculture and Animal Production of Ministry of Agriculture, Animal Production, Rural development, Fishery and Alimentation, Mexico) and ALRC.

From July 7 to July 8, we visited INIFAP (including Dr. Tsunekawa, Dr. Tsujimoto, Dr. Tomemori, Mr. Ando of ALRC and Dr. Fukui and Dr. Tsuchimoto of Osaka University) to discuss on the progress and the research plan (photo 2). From February 7 to February 13 of 2012, Dr. Alfredo Zamarripa and Dr. Victor Pecina of INIFAP were invited to ALRC to discuss research plans.

5) Division of Health and Medicine

Shinji Otani (Visiting Assoc. Prof., Health and Medicine)

The Health and Medicine Division conducts research on specific diseases in arid and semiarid areas and health disorder caused by Asian dust. The occurrence of Asian dust events is a frequent problem, with associated health issues throughout Northeast Asia. We research into comprehensive measures against Asian dust in collaboration with other groups.

The main research topics in the fiscal year 2011 were as follows:

- Evaluation on the effects of Asian dust events on the daily symptoms of healthy subjects in Japan.
- Assessment health situation and vulnerability of nomads in Mongolia.

Research grants in the fiscal year include:

- Evaluation of health effects of Asian dust

Japan Society of the Promotion of Science Grants-in-Aid for Scientific Research (C), 2011-2014 (Project Leader: S. Otani)

- Risk assessment of dust storm on animal husbandry in Mongolia
  Japan Society of the Promotion of Science Grants-in-Aid for Scientific Research (B), 2009-2013 (Project Leader: M. Shinoda)

Overseas research activities during the fiscal year 2011 include visit to Hospital of Bayan-Onjuul and inspect dust storm in Gobi Desert (photographs).

(3) Visiting Researchers

Zahoor Ahmad (Junior Assoc. Prof., Soil and Water Quality)

October 2010 – March 2011

Title: The challenge of reducing phosphorus escape from the agricultural lands to protect environment.

Summary of research activities:

Use of fertilizers is the integral part of the today's agriculture. Continues and non-judicial use of fertilizers has created sever environmental problems in many part of the world. Control of non point source of phosphorus (P) pollution is the priority management concern. Non point source of P pollution is endangering shallow ground water and drinking water bodies in many areas. Most of the waste management strategies only focused on just to prevent the soils from being polluted but good management practices are lacking for the soils which are already polluted. Therefore, it is needed to work out new strategies to protect the environment form the soils which are already polluted. One of the ways to meet this challenge is the use of some soil amendments which are effective in adsorbing the P without affecting plant wellbeing and soil chemistry. In this study some waste materials Blast furnace slag (BFS), water treatment residues (WTR)) and chemical (Hydrotalcite (HYD)) were tested for their effect on P retention capacity under soil plant system and their potential effect on plant growth and nutrient uptake.

Following experiments were conducted to test the hypothesis that above mentioned waste materials affect the P retention capacity of soil without affecting plant growth.

Experiment 1. Effect of different soil amendments on Phosphorus leaching and plant growth Materials and Methods:

A greenhouse pot experiment was conducted to evaluate the effect of BFS, WTR and HYD on the maize (*Zea mays* L.; variety: snowdento) plant growth, nutrients uptake and DRP concentration in leachate. Two soil types (Tohaku and Masa soils) were amended with WTR and BFS each at the rate of 5g per 100g soil while HYD was applied at the rate of 0.25g per 100g soil. Animal compost and chemical fertilizer (KH_2PO_4) were applied at the rate of 300 kg of total P ha^{-1}. During the seven weeks growth of maize crop, leaching was collected at one week interval from each pot and analyzed for the dissolved reactive P (DRP) concentration using ICP-AES. At harvest, plant roots were recovered from the pots, shoot and root dry matter yield was recorded, and plant tissues were analyzed for nutrient uptake.

Experiment 2. Effect of Blast furnace slag and Steel slag on the Phosphorus retention capacity of soils and plant response

Materials and Methods:

Second green house experiment was conducted with the objective to test the effect of granular blast

furnace slag and steel slag (byproducts of steel industry) on the Phosphorus leaching, plant growth and nutrient uptake. For this purpose, soil was amended with blast furnace slag (BFS) and steel slag (SS) at the rate of 0, 3, 5 and 8%. Two soil types, sandune and paddy soils were used in this study. Maize crop was used as a test crop in this experiment as well for a period of seven weeks. Chemical fertilizer (KH_2PO_4) was applied at the rate of 500 kg ha^{-1}. Leaching fraction was kept at 25% to collect the leachate. Four leachates were collected during the experimental period and analyzed for dissolved reactive P (DRP) concentration. At harvest, plant height, fresh shoot weight and dry shoot weight were recorded.

Title of Articles:

1. Zahoor Ahmad, Mohamed A. M. Abd-Elbasit, Sadahiro Yamamoto, Toshimasa Honna, and Hiroshi Yasuda (2010). Use of Two Industrial Wastes as Soil Amendments I: Effect on Dissolved Reactive Phosphorus in Runoff. Soil and Sediments Contamination (Accepted).
2. Uzoma, K.C., M. Inoue, H. Andry, H. Fujimaki, A. Zahoor and E. Nishihara (2011). Effect of Cow Manure Biochar on Maize Productivity under Sandy Soil Condition. Soil Use and Management 27 (2): 205-212.
3. Uzoma K. C., M. Inoue, H. Andry, A. Zahoor and E. Nishihara (2010). Influence of Biochar Application on Sandy Soil Hydraulic Properties and Nutrient Retention. Journal of Food, Agriculture and Environment (Accepted).

Chapter in book:

Mohamed A. M. Abd Elbasit, Hiroshi Yasuda, Atte Salmi and Zahoor Ahmad (2011). Impact of Rainfall Microstructure on Erosivity and Splash Soil Erosion under Simulated Rainfall. In: Danilo Godone (eds.) Soil Erosion, InTech OA Publisher. ISBN 978-953-307-1411-0 (In pipeline)

International Conferences:

Zahoor Ahmad, M. Abdel Basit, S. Yamamoto, T. Honna, H. Yasuda, & M. Inoue (2011). Use of blast furnace slag and water treatment residues to reduce the runoff of dissolved reactive phosphorus from agricultural lands. In: V. Popov and Brebbia C.A. (eds.) Food and Environment, 21 - 23 June 2011, New Forest, UK.

Seminars:

1. Use of different soil amendments to protect the environment from phosphorus pollution. Arid land research center, February 8, 2011. ALRC.
2. Food and Agriculture of Pakistan, June 6, 2011. ALRC.

Results of the Experiments:

Experiment 1:

Results of the study revealed that total mean plant dry matter yield was not significantly affected by the two soil types. However, fertilizer types significantly affected the plant dry matter yield in each soil type. In both soils, plant dry matter yield was higher in the pots amended with inorganic P fertilizer as compared to the compost. Effects of the soil amendments on dry matter yield also varied under the two soil types. In the Masa soil, plant dry matter yield was slightly lower in pots amended with BFS, WTR and HYD as compared to control but in Tohaku soil dry matter yield was slightly higher in BFS, lower in WTR

and equally higher in HYD amended pots when compared with the control treatment.

Analysis of leachate collected over the time shows that DRP concentration significantly varies among the two soil types. Overall DRP concentrations in leachates were higher from Masa soil as compared to the Tohaku soil. In Masa soil, DRP concentrations were slightly higher from Inorganic P amended pots at the start of the experiment, but at third week DRP concentration reduced in leachate as compared to the compost amended pots. All the soil amendments significantly reduced the DRP concentration in leachate collected from Masa soil. In Tohaku soil, DRP concentrations were slightly higher from compost amended pots as compared to the chemical P amended pots. While the effects of soil amendments on P leaching were not obvious in Tohaku soil.

Phosphorus uptake data showed that P uptake was higher in maize shoot grown in Masa soil as compared to Tohaku soil. Among the soil amendments, maximum mean shoot P uptake was recorded in control followed by HYD, BFS and WTR. However, P uptake was greatly affected by the soil type. Phosphorus uptake pattern was the same in Masa soil as stated earlier but in Tohaku soil affect of soil amendments on P uptake was not significant.

It can be concluded that BFS, WTR and HYD are effective in reducing P concentration in leachate, especially from coarse textured soils. Soil amendments slightly affected the plant growth and nutrient uptake of maize shoots grown in Masa soil (not in clayey soil) in this pot experiment. There is need to conduct further field studies (with different soil types and application rate) to evaluate the effect of these amendments under field condition. Effect of soil amendments were less obvious in Paddy which could be due to the higher concentration of native amorphous Al and Fe (Oxalic acid extractable) contents of the soil.

Experiment 2:

During the experiment four leachates were collected to analyze the DRP concentration in leachate. Results of the leaching showed that overall mean DRP concentrations were from sandy soil as compared to clayey soil. Among the treatments, it was observed that both BFS and SS were equally effective in reducing DRP concentration in leachate. However, effect of these soil amendments was much clear in sandy soil than the clayey soil. It was observed that both amendments were highly effective in reducing DRP leaching and no change was observed within different application rates.

Mean plant height was recorded at harvest. It was observed that mean plant height was higher in BFS amended pots as compared to SS treatments under both soil types. In sandy soil, application rate of 3% (both BFS and SS) slightly increased the plant height as compared to control. In clayey soil, SS at 3% application rate increased the plant height in sandy soil but higher application rates reduced the plant height when compared with control treatment. In clayey soil, all application rates of SS reduced the plant height as compared to the control.

Plants were harvested after seven weeks to record the dry matter yield (DMY). Results showed that maize shoot DMY was higher from clayey soil than the sandy soil. Overall mean DMY was higher in BFS amended pots as compared to SS treatments. In the Paddy soil, no much variation was observed in shoot DMY with increasing the BFS application rate from 0 to 8%. On the other hand, increase in maize shoot DMY was observed with increase in BFS application rate. Contrary to BFS, increased application rates of SS reduced the DMY of maize shoot in both clay and sandy soils.

Jugder Dulam (Prof., Meteorology)

April 2011 – March 2012

Title: Dust emission processes in Mongolia.

Summary of research activities:

Dust events in the extensive Gobi and desert-steppe zones of Mongolia occur frequently and sometimes cause serious disasters. It poses a serious threat to human life, livestock and economic activities in a short-term period. Dust events can have long-term and widespread effects including sand accumulation, sandy dune movement, soil erosion, land degradation, desertification, etc. Human activities in Mongolia such as mining, transportation of natural resources via unpaved roads, livestock grazing, forest-steppe fairs, etc, can potentially induce anthropogenic land degradation enhancing dust event occurrences.

Natural and anthropogenic dust can be transported from source regions to downstream regions. The study of dust events and its transport and deposition is an area of growing importance in investigations of regional and global environmental changes, and dust storm monitoring can show evidence of environmental changes. A new monitoring network for dust events including particulate matters in the air was established in Mongolia from 2007 to 2010 with collaborations of China, Japan, Korea and Mongolia. Particulate matter in the air is usually divided into populations with aerodynamic diameters less than 10 μm (PM_{10}), 2.5 μm ($PM_{2.5}$), or 1.0 μm ($PM_{1.0}$) and is measured by instruments near the ground surface and by lidar in the troposphere. Based on the quantitative data obtained from the network, I have been doing researches with the theme "Dust emission processes in Mongolia" at the Arid Land Research Center of Tottori University, Japan in the fiscal year 2011. The study results are given in the Section 3.

I have attended in the regular (weekly) seminars organized by a research division of the Climatology and Water Resources and gave own seminar to the Climatology Laboratory staff on the following topic:

Seminar 1: Estimation of dust emission threshold wind in dry land areas of Mongolia, *The Laboratory of Climatology*, ALRC, Tottori University, Japan, 24 January 2012.

While I participated to the open seminars given by other Visiting Researchers, I gave my own open seminars with topics below:

Open seminar 1: Networking of dust studies in East Asia, 06 June 2011.

Open seminar 2: Natural disasters in Mongolia, 27 February 2012.

I have participated in lectures by researchers invited from other universities or institutes of Japan as well as worldwide at the ALRC. I gave comments on two different workshops/seminars organized by the Laboratory of Climatology, ALRC that are the International Workshop on Drought in an Arid Cold Region, in 02 August 2011, and International Workshop on Dust in 23 February 2012. I have also participated in international workshops and seminars and gave oral presentations with topics as below:

Oral presentation 1:

Jugder D., Shinoda M., Sugimoto N., Matsui I., Nishikawa M., Park S.U., Chun Y.S. and Park M.S., 2011, Spatial and temporal variations of dust concentrations in the Gobi Desert of Mongolia, *Joint seminar between ALRC and Institute of Meteorology and Hydrology (IMH), Mongolia for the 45th Anniversary of IMH, Ulaanbaatar, 01 July 2011.*

Oral presentation 2:

Jugder D., and M.Shinoda, Dust emission early warning system in Mongolia, *The side event of "Asian dust and desertification" organized by the ALRC, Tottori University, Japan at the UNCCD COP10, Changwon, Gyeongnam Province, Republic of Korea, October 11, 2011.*

Oral presentation 3:

Jugder D., M.Shinoda, N.Sugimoto, I.Matsui, M.Nishikawa, S.U.Park, Y.S.Chun and M.S.Park,

Spatial and temporal variations of dust concentrations in the Gobi Desert of Mongolia, *The American Geophysical Union (AGU) Fall Meeting 2011, Session A42A-05, Aerosols in Urban and Rural Environments: Sources, Transformations, Properties, and Atmospheric Effects VII, San Francisco, California, USA, 5-9 December 2011*.

In the Seminar of Joint-Use Researches organized by the ALRC on 3-4 December 2011, I have illustrated a poster presentation and the title is below:

Poster presentation 4: D. Jugder, M. Shinoda, N.Sugimoto, I.Matsui, M.Nishikawa. Dust, biomass burning smoke, and anthropogenic aerosol detected by polarization-sensitive Mie lidar measurements in Mongolia. The Seminar of Joint-Use Researches, ALRC, Tottori University, Japan in 3-4 December 2011.

In addition, for a purpose of the site survey establishing dust monitoring site, I have worked together with teams of the Dust Project by ALRC at Tsogt-Ovoo Soume of Umnogobi Aimag, Mongolia in 29 June to 25 July and 13-26 September 2011. The results were reported to the ALRC.

Served as a Member of the Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) - Regional Steering Group (RSG) for Asian node: The Third Meeting of the RSG for Asia, WMO SDS-WAS, 7-8 March 2012, Tsukuba, Japan, hosted by Meteorological Research Institute (MRI).

Title of articles:

1. Printed article:

   Jugder, D., M. Shinoda, N. Sugimoto, I. Matsui, M. Nishikawa, S.U. Park, Y.S. Chun and M.S. Park, Spatial and temporal variations of dust concentrations in the Gobi Desert of Mongolia, *The International Journal of Global and Planetary Change*. (Available online: 13 May 2011)

2. Accepted article:

   D. Jugder, M. Shinoda, N.Sugimoto, I.Matsui, M.Nishikawa, Dust, biomass burning smoke, and anthropogenic aerosol detected by polarization-sensitive Mie lidar measurements in Mongolia, The Journal of Atmospheric Environment. (Accepted on 24 January 2012)

3. The article in preparation:

   D.Jugder, M.Shinoda, R.Kimura, N.Sugimoto, I.Matsui, A.Shimizu and M.Nishikawa. Estimation of dust emission threshold wind in dry land areas of Mongolia, The International Journal of Atmospheric Environment.

Results of the researches:

Result 1: Spatial and temporal variations of dust concentrations in the Gobi Desert of Mongolia

This study was the first to examine quantitative data on dust storms using dust concentrations (PM_{10} and $PM_{2.5}$) observed at four sites in the Gobi Desert of Mongolia. One of our goals was to find characteristic features of dust storms in these data. We analyzed annual and diurnal variations of PM_{10} and $PM_{2.5}$ concentrations associated with dust storms during 2009–2010, and made a case study of the dust storm of 26–27 May 2008 using mass concentrations of PM_{10} and $PM_{2.5}$ as well as vertical profiles obtained by lidar.

The present study showed that annual mean PM_{10} ($PM_{2.5}$) concentrations during 2009 were 47 (34) μg m^{-3} at Dalanzadgad, 49 μg m^{-3} at Erdene, and 9 (5) μg m^{-3} at Sainshand. Monthly mean PM_{10} concentrations were higher in cold months (November to February) and in spring (March to May). Monthly mean PM_{10} ($PM_{2.5}$) concentrations reached a maximum in December 2009 with values of 120 (94) μg m^{-3} at Dalanzadgad, about 60 (38) μg m^{-3} at Zamyn-Uud, 8 (4) μg m^{-3} at Sainshand, and 89 μg m^{-3} at Erdene.

Large amounts of fine dust particles are emitted to the air during the dust storm period in the Gobi Desert of Mongolia. Daily mean PM_{10} ($PM_{2.5}$) concentrations for dust storms exceeding 6 h were 198 (115) μg m^{-3} at Dalanzadgad, 64(40) μg m^{-3} at Sainshand, 119 (67) μg m^{-3} at Zamyn-Uud, and 234 μg m^{-3} at Erdene. Daily mean maximum PM_{10} ($PM_{2.5}$) concentrations were as high as 821 (500) μg m^{-3} at Dalanzadgad, 308 (129) μg m^{-3} at Zamyn-Uud, and 1328 μg m^{-3} at Erdene during dust storms. The highest hourly mean PM_{10} ($PM_{2.5}$) concentration during the study period was 6626 (2899) μg m^{-3} at Dalanzadgad. The observed data at the sites showed dust storms representatively in the Gobi Desert in each season.

During the heavy dust storm period of 26–27 May 2010, measurements at Zamyn-Uud showed that PM_{10} concentrations reached 1228 μg m^{-3}, visibility ranged from 300 to 700 m, gusty winds reached 24 m s^{-1}, and the dense dust layer was observed up to 0.5 km above the land surface due to the primary cold front. On next days (27–28 May), the dust elevated owing to the secondary cold front, reaching about 3 km height. The records of attenuated backscatter coefficients, the depolarization ratio and the extinction coefficient indicated a very high concentration of dust during 26–28 May 2008.

High concentrations of PM_{10} and $PM_{2.5}$ were related to both natural and anthropogenic sources of particulate matter. The two sources were distinguished in term of the threshold daily maximum wind speed of 6 m s^{-1}; high concentrations accompanied by the strong winds exceeding the threshold wind are likely derived from dust storms, while those with calm weather conditions may be due to the anthropogenic aerosols. A natural source was dust storms developed by the passage of cyclones accompanied by cold fronts. Anthropogenic aerosols were found to be high around Dalanzadgad and Zamyn-Uud, and natural dust particles were high around Erdene. However, the number of dusty days at Dalanzadgad in 2009 was considerably higher than normal. Anthropogenic sources may include burning of coal in population centers. The maximum PM_{10} and $PM_{2.5}$ concentrations occurred in the morning and evening, coinciding with coal usage in private houses. It is evident that human activities can affect local air quality around urban localities in the Gobi of Mongolia. Afternoon peaks in PM_{10} and $PM_{2.5}$ concentrations appear to be due to dust storms.

Result 2: Dust, biomass burning smoke, and anthropogenic aerosol detected by polarization-sensitive Mie lidar measurements in Mongolia

For investigations of regional environmental changes, northeast Asian countries have various activities, one of them is dust storm monitoring using lidars. By the support of Japan International Cooperation Agency (JICA), three lidars were installed in Mongolia in 2007. The Mongolian lidars are included in lidar network of the National Institute for Environmental Studies, Japan, which currently consists of 20 sites in Japan, Korea, China, Thailand, and Mongolia. The lidar network data are used for real-time monitoring of Asian dust as well studies on regional dust events and air pollution, direct radiative forcing, and climate change. The purpose of the lidar network in Mongolia is to reveal the spatial and temporal distributions of dust events in the Gobi Desert and to study the ambient air quality of the capital city.

The study is the first to reveal vertical profiles of atmospheric aerosols in Mongolia, which include dust events, biomass burning smoke, and air pollution events, and to identify source areas of elevated dust layers in the air and anthropogenic aerosols based on the recently established network of polarization-sensitive Mie-scattering lidars. Moreover, threshold winds for dust emission were determined, and transport routes by an aerosol transport model for dust emissions and aerosol origins were presented using backward air trajectories.

For the study of temporal and spatial distributions of dust events in Mongolia, lidar measurements

from the end of 2007 to the first half of 2010 were used. Out of dust storm events in the Gobi Desert during May 2008, severe dust events with high lidar-extinction coefficients of 0.3-0.74 km^{-1} were observed on 19–20 and 26–27 May. The lidar observations revealed the dense dust layer in the Gobi Desert in 19-20 May with top heights of 2-3 km AGL caused by the dust event. The maximum wind speed was 18-22 m s^{-1}, horizontal visibility reduced to 1 km or less during 7-8 hours with lowest visibilities of 189 m at Sainshand and 319 m at Zamyn-Uud that coincided roughly with peaked PM_{10} ($PM_{2.5}$) of 1139-1409 (384-404) µg m^{-3}. The threshold wind speeds for dust emission at 4 m AGL were determined as 10.0 m s^{-1} for Sainshand and as 6.0 m s^{-1} for Zamyn-Uud during the dust events of 17-20 May 2008. These threshold speeds for the Gobi Desert are lower than that in the Mongolian steppe. Dust concentrations of PM_{10} had good relationships with visibilities during the dust event.

The study results of statistical analyses show that the vertical structures of dust events are diverse. The lidars indicated that the maximum height of dust layers over the Gobi Desert of Mongolia during dust event periods varied from 0.5 to 5.5 km. The average maximum heights of dust layers during dust event periods were around 2.2 km at Zamyn-Uud and 2.0 km at Sainshand. The 95^{th} percentile level of dust vertical profiles was found at 4.0-4.5 km for those sites.

The Mie lidar observations detected elevated dust layers. The base heights of the elevated dust layers ranged from 0.5 to 2.5 km, and the top heights from 2.5 to 4.5 km in the atmosphere. The elevated dust layers were associated with residual dust layers after passages of cold fronts with dust events or those of weak low pressure systems at the Gobi Desert areas. The study results suggested source areas of the elevated dust that was transported from other source regions to the Gobi Desert of Mongolia.

The lidar measurements at Ulaanbaatar, Sainshand, and Zamyn-Uud detected biomass burning smoke extending from the ground level up to the mid-troposphere as well as elevated in the air. The backward trajectory analyses showed that the source areas of the biomass burning smoke were southern Siberia and the northern forest area of Mongolia. The lidar parameters at Sainshand and Zamyn-Uud revealed transported anthropogenic aerosol episodes in southeastern and eastern Mongolia that extended from the ground level up to 3 km AGL. According to backward air trajectory analyses on some cases, polluted air masses came from the central and southeastern regions of China to the southeastern and eastern terrain of Mongolia.

Result 3: Estimation of dust emission threshold wind in dry land areas of Mongolia

Dust events are generated by the erosion of surface materials in dry land areas. Dry and loose sediments unpaved or paved scarcely by vegetation in any soils can be blown in to the atmosphere. However, main sources of mineral dust are located in the Gobi Deserts (Goudie and Middleton, 2006, Natsagdorj et al., 2003). In Mongolia, 34.6% of territory is the dry land areas, of which 28.4%-Desert steppe (Gobi) and 6.2%-the Desert. Dust events may occur under synoptic meteorological conditions that is the passage of low-pressure fronts with intense baroclinical gradients, which are accompanied by high velocity winds entraining and carrying dust.

In combination of above two causes, dust storms result from erosion and deflation of surface materials by a threshold wind speed. The threshold velocity is the minimum wind speed required to initiate deflation of surface sediments. At this velocity, the aerodynamic drag on the surface is enough to dislodge particles from the ground surface, to set them in motion and to lift them into the atmosphere. The threshold velocity depends on a number of surface properties.

Based on recently established new measurements of dust flux with meteorological parameters in the

dry land areas of Mongolia, this study aimed to show statistics of dust concentrations of PM_{10} ($PM_{2.5}$) and the surface meteorological data measured synchronically with dust flux, to illustrate relationships between wind speed, dust flux and visibility and to estimate dust emission threshold wind in the steppe and Gobi Deserts in Mongolia.

Statistical analyses show good correlations between parameters, such as the correlations was negative and -0.33 to -0.96 between visibility and PM10, 0.25 to 0.52 between wind and PM10 and -0.41 to -0.63 between wind and visibility. The 95% confidence intervals of hour mean PM10 ($PM_{2.5}$) concentrations were 84-120 (39-57) μg m^{-3} at Dalanzadgad, 58-89 (28-42) μg m^{-3} at Sainshand, 136-170 (44-54) μg m^{-3} at Zamyn-Uud, 313-386 at Erdene and 85-135 μg m^{-3} at Bayan Unjuul during dust event days. The 95% confidence intervals of hour-mean winds were 6.5-6.9 m/s at Dalanzadgad, 8.5-9.5 m/s at Sainshand, 6.8-7.2 m/s at Zamyn-Uud, 7.8-8.2 m/s at Erdene and 4.0-4.5 m/s (at1.54 m) at Bayan Unjuul during dust events. The 95% confidence interval of the hour mean relative humidity was 33.3-36.1% at Erdene during dust events. High standard deviations of PM_{10} ($PM_{2.5}$) indicated that the data of PM_{10} ($PM_{2.5}$) were spread out over a large range of values.

Using observed values of dust concentration of PM_{10} and wind speed, the empirical constant (*c*) was estimated at 0.0192 for Dalanzadgad, 0.0035 for Sainshand, at 0.0267 for Zamyn-Uud, 0.0258 for Erdene and 0.063 for Bayan-Unjuul. Using PM10 is 50 μg m^{-3} for dust emission (Igarashi et al., 2009, Kimura/Shinoda, 2010), threshold winds at the 4 m level were estimated. The threshold wind speed at the 4 m AGL during days with dust events was estimated with the Eq. (1) as 7.1 m s^{-1} for Dalanzadgad, 10.9 m s^{-1} for Sainshand, as 6.6 m s^{-1} for Erdene, as 6.58 m s^{-1} for Zamyn-Uud in 2009-2011 and as 5.46 m s^{-1} at 1.54 m level for Bayan-Unjuul in May 2008.

Nigussie Haregeweyn Ayehu (Assoc. Prof., Soil Erosion and Conservation)

April 2011 – March 2012

Title: Improving climate adaptation strategies through a comprehensive understanding of climate: a case of Ethiopia

Summary of research activities:

The Ethiopian drylands which account for 67% of the country and the agriculture sector have been identified as the most vulnerable to drought and land degradation due to soil erosion. As a result, Ethiopia is often characterized by major national and local droughts. In Ethiopia as a whole, however, the issue of conserving land was largely neglected until the early 1970s, when awareness of the problem was initiated by the devastating famine that happened in Wello in 1973 and 1974. Since the early 1980s, land conservation efforts have been further expanded with involvement of the World Food Program and similar initiatives that provided food-for-work incentives for conservation activities. Since the last decade, however, soil and water conservation (SWC) and water harvesting interventions have been widely implemented to increase the adaptive capacity and reduce the vulnerability to climate variability mainly in the drylands of Ethiopia.

There is generally a lack of comprehensive study to what extent land use/ land cover changes as well as integrated watershed management interventions have the desired effect in land improvement. Moreover, data on sediment yield and reservoir sedimentation rates for Ethiopia are not only limited in number and space but they are also unreliable. Moreover, adoptable erosion and sediment yield models, which are important tools for appropriate land management, are currently lacking. Therefore, as a follow up of my

first year's research work as a Visiting Researcher based at the Plant Production Division of the Arid Land Research Center (ALRC), Tottori University, a research topic entitled "Improving climate adaptation strategies through a comprehensive understanding of climate: a case of Ethiopia" has been adopted over the last one year (April 2011-March 2012).

The main specific tasks during this period included: analysis, write up and/or finalization of six scientific papers dealing with reservoir sedimentation assessment and modeling, land use/land cover change, where the specific details of each are given under Section 3. I have also participated in jointly planned researches, attended and gave seminars, participated in an international conference, and also served as scientific committee member for international conferences, where each of them are described below:

- Participated along with (mainly) Plant Production Division staff of the center in a jointly planned researches being carried out through PhD students such as participating in regular (every two weeks) seminars, regular meetings at Division level, and review of students' papers, and a PhD thesis Examination Board member;
- Attended several seminars given by other Visiting Researchers, invited researchers as well as gave my own seminars to the staff and students of the ALRC on the following two different topics: (1) seminar 1: understanding environmental change through a repeat photography technique, 06 June 2011, and (2) seminar 2: Water resources development in Ethiopia: opportunities and challenges with emphasis on trans-boundary rivers, 27 February, 2012;
- Invited Speaker at Soils-sediment and Carbon workshop, Berne, Switzerland, 28-30 July, 2011, organized by PAGES (Past Global Changes) on the topic entitled "Sediment and carbon dynamics at various spatial/temporal scales in the Ethiopian highlands";
- Conducted filed work in Ethiopia (01– 26 September, 2011): The activities included learning research undertakings on *Prosopis juliflora (Swartz*) by FARMAfrica and SOS-USA, sharing experience in the water resources development for irrigation as climate adaptation intervention, sharing experience in natural resources management - climate adaptation and mitigation interventions, acquisition of climate data from Ethiopian National Meteorology Agency (NMA) and regional branch offices; and,
- Served as member of international scientific committees: (1) Geomorphology 2011: Regional Conference: Addis Ababa, February 18-22, 2011 and (2) International Congress: Integrated Water Resources Management in Tropical and Subtropical Drylands, Mekelle, Ethiopia, September 2011.

Title of articles:

* Haregeweyn, N., Poesen, J., Govers, G., Verstraeten, G., de Vente, J. Nyssen, J., Deckers, S., Moeyersons, J., 2011. Evaluation and adaptation of a spatially-distributed erosion and sediment yield model in Northern Ethiopia. Land Degradation and Development, in press. DOI: 10.1002/ldr.1121

* Haregeweyn, N., Melesse, B., Tsunekawa, A., Tsubo, M., Meshesha, D. Balana B.B., 2012. Sedimentation and its mitigating strategies: a case study of Angereb reservoir, northwestern Ethiopia. Journal of Soils and Sediment, 12: 291-305.

* Haregeweyn, H., Fikadu, F., Tsunekawa, A., Tsubo, M., Meshesha D., 2012. The dynamics of urban expansion and its impacts on land use/land cover change and small-scale farmers living near the urban fringe: a case study of Bahir Dar, Ethiopia. Journal of Landscape and Urban Planning, in press, DOI: 10.1016/j.landurbplan.2012.02.016.

* Haregeweyn N., Gebrekiros, A., Tsuenkawa, A., Tsubo, M., Meshesha, D., Yazew E., 2011. Performance Assessment and Adoption Status of Family Drip Irrigation System in the Tigray Regional

State, Northern Ethiopia. In: Manoj J. (ed.) Water Conservation. In Tech, Rijeka, Croatia. ISBN 978-953-307-960-8.

* Haregeweyn, H., Berehe A., Tsunekawa, A., Tsubo, M., Meshesha D., 2012. Integrated watershed management, an effective approach to curb land degradation: a case study of the Enabered watershed, northern Ethiopia. Journal of Environmental Management, Springer, resubmitted after revision.

* Haregeweyn, N., Negash, A., Tsunekawa, A., Tsubo, M., Meshesha, D. Analysis of the invasion rate, impacts and control measures of *Prosopis juliflora* (Swartz) DC: a case study of Amibara District, Afar Regional State, Ethiopia, to be submitted soon.

* Haregeweyn, N., Kiros H., Tsunekawa, A., Tsubo, M., Meshesha, D., Identification of critical regions and seasons for effective water resources development interventions in Northern Ethiopia, under preparation.

* Balana, B.B., Muys, B. Haregeweyn, N., Descheemaeker, K. Deckers, J., Poesen, J., Nyssen, J., Mathijs, E., 2012. Cost-benefit analysis of soil and water conservation measure: The case of exclosures in northern Ethiopia. Forest Policy and Economics, 15: 27-36.

* Meshesha, D.T., Tsunekawa, A., Tsubo, M., Haregeweyn, N., 2011. Spatial analysis and semi-quantitative modeling of specific sediment yield in six catchments of the central rift valley of Ethiopia. Journal of Food, Agriculture and Environment, 9(3-4): 784-792.

* Meshesha, D.T., Tsunekawa, A., Tsubo, M., Haregeweyn, N., 2012. Analysis of the dynamics and hotspots of soil erosion and its management scenarios: the case of the Central Rift Valley of Ethiopia. International Journal of Sediment Research, in press.

* Zenebe, A., Vanmaercke, M., Poesen, J., Verstraeten, G., Haregeweyn, N., Haile, M., Amare, K., Deckers, J., Nyssen J., 2012. Spatial and temporal variability of river flows in the degraded semi-arid tropical mountains of northern Ethiopia. Zeitschrift für Geomorphologie, in press.

Result of the research:

Paper 1: Evaluation and adaptation of a spatially-distributed erosion and sediment yield model in Northern Ethiopia.

Most regional-scale soil erosion models are spatially-lumped and hence have limited application to practical problems such as evaluation of the spatial variability of soil erosion and sediment delivery within a catchment. Therefore, the objectives of this study were: (1) to calibrate and assess the performance of a spatially-distributed WATEM/SEDEM model in predicting absolute sediment yield (SY) and specific sediment yield (SSY) from 12 catchments in Tigray (Ethiopia), using two different sediment transport capacity equations (original and modified) and (2) to assess the performance of WATEM/SEDEM for identification of critical sediment source areas needed for targeting catchment management. The performance of the two model versions for SY was found promising for the 12 catchments. For both versions, model performance for the nine catchments with limited gully erosion was clearly better than the performance obtained when including the three catchments with significant gully erosion. Moreover, there is no significant difference (alpha 5%) between the performances of the two model versions. Cultivated lands were found to be on average five times more prone to erosion than bush-shrub lands. The predicted soil loss values in most parts of Gindae catchment are generally high as compared to the soil formation rates. This emphasizes the importance of implementing appropriate SWC measures in critical sediment source areas prioritizing the steepest part of the catchment (i.e., areas with slope >50 %). The applicability of the WATEM/SEDEM model to environments where gully erosion is important requires the

incorporation of permanent gully and bank gully erosion in the model structure.

Paper 2: Sedimentation and its mitigating strategies: a case study of Angereb reservoir, northwestern Ethiopia.

The Angereb dam in northwestern Ethiopia was commissioned in 1997 to serve as a domestic water supply for 25 years. However, its sustainability is being threatened by rapid sedimentation. The overall objective of this study was to better understand reservoir sedimentation in this tropical highland watershed and to propose its mitigating strategies that would contribute to improved planning and management of reservoirs in similar regions. The reservoir's surface area and capacity at every 1-m elevation difference were generated based on point (x,y,z) data collected by bathymetric surveys in 2005 and 2007. Rates of reservoir capacity loss and sediment yield during 1997–2005, 1997–2007, and 2005–2007 were calculated, and the life of the reservoir was projected. Then, an identification of sediment mitigating strategies was done by employing a multi-criteria decision analysis (MCDA) technique. The annual total capacity loss during 1997–2005, 1997–2007, and 2005–2007 was estimated at 4.02%, 3.16%, and 3.03%, respectively, and the relatively decreasing trend is attributed to the impact of limited soil and water conservation practices implemented in the watershed at the later stage of the dam project. Comparison of capacity–elevation–area curves between 2005 and 2007 showed that sediments were distributed across the reservoir floor, though most (68%) deposition occurred below the dead storage level. The actual life of the Angereb reservoir was projected to be 3 years, which means that the remaining dead storage capacity will be silted up completely by the end of the rainy season in 2011. The rapid sedimentation is due to both technical and environmental factors. Both curative and preventive sediment management strategies were proposed: (1) removal of sediment using machinery or manual labor and promoting use of the sediments for farmland reclamation, and (2) implementation of specific area-targeted watershed management interventions. In the short-term, the reservoir life can be extended by raising the intake level of the pump suction pipe. For sustainable dam and reservoir design, top priority should be given to reliable sediment yield database building, development and adoption of appropriate methodologies for predicting sediment yield, and capacity building of designers.

Paper 3: The dynamics of urban expansion and its impacts on land use/land cover change and small-scale farmers living near the urban fringe: a case study of Bahir Dar, Ethiopia.

This study evaluated the dynamics of urban expansion and its impacts on land use/land cover change and livelihoods of small-scale farmers living near the urban fringe of Bahir Dar in northwest Ethiopia. Aerial photos for the years 1957, 1984, and 1994 as well as field mapping using GPS for the year 2009 were employed and analyzed using GIS. Heads of 271 households affected by the expansion were interviewed to evaluate the impacts of expansion and compensation modalities in practice. Results showed that the urban area expanded annually by about 12%, 14% and 5% during the periods: 1957-1984, 1984-1994 and 1994-2009, respectively. The area showed an overall annual increment of 31%, from 279 ha in 1957 to 4,830 ha in 2009. Built-up areas increased as a result of horizontal expansion, from 80 ha in 1957 to 848 ha in 1994, but also due to intensification at the expense of agricultural areas, from 80 to 155 ha, during the same period. A total of 242.2 ha of farmland was expropriated from 271 households between 2004 and 2009, and 96% of those interviewed believed that the compensation was insufficient, as the decision is influenced by the government's land ownership system. We predict that the current urban area will double by 2024. This will have far-reaching ecological, socio-economic and environmental impacts. A

better understanding of the dynamics of urban growth and its associated impacts in the urban fringe can help form a basis for sustainable planning of future developments of areas experiencing urban expansion.

Paper 4: Performance Assessment and Adoption Status of Family Drip Irrigation System in the Tigray Regional State, Northern Ethiopia.

Since the last 5 years, family-drip irrigation (FDI) system has been implemented in the Tigray Regional State, as an option for irrigation water saving at household level. The main aim of this study was therefore to assess the performance and adoption status of this FDI system. The performance evaluations were based on emission uniformity (Eu) and flow variation (q_{var}) measured 3 times at 32 locations, total suspended solids (TSS) of the water sources, and water demand-supply level of two test crops under FDI system and its adoption rate and trend. The results showed that Eu did not vary significantly with an average value of 94 %, which is categorized within an excellent range. A flow variation (q_{var}) ranging between 0.068 and 0.05 was found to be within the desirable range. The water sources have a TSS values ranging between 96 and 144 mg/l which fall in a moderate to severe range with regard to emitter clogging hazard. Furthermore, the irrigation water application is found to be deficient of the crop water demand in that the total water deficit during the growing season is estimated at 62% and 52% for onion and tomato test crops respectively. Though, the distribution trend has shown a marked increase temporally, the number of working FDI kits at field level was found to be only 55%. The main reasons for the slow FDI dissemination and adoption were not due to technical problems with the technology but was mainly due to the lack of training and demonstration at farmers' level about the technical and operational requirements, which calls for a concerted effort to be done in that line . However further research is also needed on evaluation of the economic feasibility of the FDI system.

Paper 5: Integrated watershed management, an effective approach to curb land degradation: a case study of the Enabered watershed, northern Ethiopia.

Integrated watershed management (IWM) is an advanced land management approach that has been widely implemented in Tigray region of Northern Ethiopia since 2004. The general aim of this study was to analyze to what extent IWM approach is effective in curbing the land degradation problem in the fragile drylands such as in the Enabered watershed in Tigray. This study assessed the impacts of IWM on (1) land use and land cover change and (2) reduction of runoff loss and soil loss due to sheet and rill, and gully erosion. Watershed characteristics and implemented IWM measures were mapped in the field and changes in land use/land cover and runoff and soil losses were compared before (2004) and after (2009) the IWM interventions. Plantations and exclosures showed a significant increase at the expense of grazing and bushlands. Runoff and sheet and rill erosion decreased by 27% and 89%, respectively, while gully channels were reclaimed. The decrease in sheet and rill erosion resulted from changes in crop and cover (48%) and conservation practice (29%) factors, as represented by *C* and *P* of the Universal Soil Loss Equation. The results revealed that land degradation has been curbed as a result of IWM intervention. The effective implementation of the main components of IWM approach through participation of the local community including contribution of 20-days of free labor was the key factor for this success. Hence IWM may be implemented in other regions with similar environmental and socioeconomic situations.

Paper 6: Analysis of the invasion rate, impacts and control measures of *Prosopis juliflora* (Swartz) DC: a case study of Amibara District, Afar Regional State, Ethiopia.

Prosopis juliflora (Swartz) DC (*P. juliflora*) is a shrub or small tree which was first introduced to the Afar Regional State in Eastern Ethiopia in the 1970s with the main aim of curbing the desertification problem in the country. The Afar State as well as some non-governmental organisations is looking for ways to commercialize the tree's wood, while pastoralists who often call it the "Devil Tree" insist on its eradication as they claim that it is invading their grazing lands. However, so far there was no any systematic study made to understand the invasion rate and its associated impacts that could lead to identification of appropriate management interventions. The objective of the study was therefore to quantify the invasion rate of *P. juliflora*, analyze its impacts and identify and evaluate the control management options under practice in the study area. The invasion rate was determined through land use and land cover (LULC) change detection using Landsat imagery data of years 1973, 1987, 1999 and 2004 in a GIS environment. The impacts and evaluation of *P. juliflora* management options were carried out using field survey and interviews. *P. juliflora* was found to invade new areas at an average rate of 3.45 km^2/annum from 1973-2004. If the current trend continues, about 163.064 km^2 (30.89%) of the study area would be under *P. juliflora* by the year 2020. Our survey shows that invasion of *P. juliflora* causes loss of biodiversity and ecological services, affecting the livelihoods and health of the pastoralist and agro-pastoralist. If properly managed, however, it will have positive implications on the soil amelioration, micro-climate regulation and income generation for charcoal makers. On the other hand, the pastoralist and agro-pastoralist still insist on its immediate eradication because for them under the current management system the disadvantages outweigh the advantages. However, the current villigization program to transform nomads to sedentary farmers could be a possible win-win solution to address the problem associated with *P. juliflora*. Further research is necessary to find out the most efficient management and exploitation techniques of *P. juliflora* tree in the region.

Abdelbagi Mukhtar Ali (Prof., Molecular Breedings)

October 2011 – September 2012

Title: Basic research on breeding of stress-tolerant wheat by genetic engineering

Summary of research activities:

Wheat belongs to the Triticeae tribe which has more than 300 species that are distributed across all continents except Antarctica. Most of the genetic resources of tribe Triticeae have never been used in the history of agriculture, though most of the species are able to be crossed with wheat. Many wild species in tribe Triticeae inhabit harsh environments in cold, humid, saline and dry regions, where wheat cannot survive. Some genes from the wild relatives, mainly disease resistant genes, have been used in wheat breeding; however, these constitute a very small portion of the useful genes present in the tribe Triticeae. Very useful synthetic materials have been developed by crossing wheat with alien relatives and maintained in Tottori Alien Chromosome Bank of Wheat (TACBOW) supported by the National BioResource Project–Wheat (Japan). Useful traits from TABOW materials have already been reported such as unique seed storage proteins (Garg et al. 2010) and fertilizer use efficiency (Wang et al 2010, 2011). A line containing a chromosome of *Leymus racemosus* was found to secrete an unidentified substance(s) from the roots that inhibits the growth of nitrobacteria. Thus, this line uses nitrogen fertilizer more efficiently than standard wheat cultivars, and in addition, inhibits emission of nitrous oxide (N_2O), which is known to be a more potent greenhouse gas than CO_2 (Subbarao et al. 2007). Recently, some lines were identified to have high phosphorus uptake and phosphorus use efficiencies (Wang et al. 2010). Since phosphorus resources are predicted to have depleted by the end of this century, the variation introduced from wild species will be

useful for wheat breeding programs. As shown by these examples, the genetic diversity of alien species is extremely valuable for human crop breeding and food production. The effective utilization of these valuable resources to enhance the adaptation of cultivated wheat to our changing climate, worming globe and expanding aridity would be of paramount importance. Understanding the genetic makeup and transferring these genetic resources into Farmer Preferred wheat varieties will pave the way for more food and better sustainable agricultural production in arid regions.

In this context the following experiments were conducted or initiated during the first 6 month of my research visit period:

a. Mapping of useful adaptation genes for hot dry environment in wheat-alien recombinant inbred lines (RILs);
b. Development of multiple synthetic populations in farmers preferred wheat varieties background for hot dry environment;
c. Evaluation of Genotype by Environment interaction for wheat bread making quality under hot dry Environment.

The progress so far made in each of the above experiments can be summarized as follows:

a. One hundred-twelve RILs developed from the cross of the wheat variety Chinese Spring and the synthetic hexaploid (*T. carthlicum stramineum* X *Ae. Taushii*) were grown in a replicated evaluation trail under hot dry environment in the wheat program research field at the Gezira Research Station, Wad Medani, Sudan. The RILs together with their parents and local check varieties were planted in a Randomized Complete Block Design trail with two replications. The plot size was 0.5m X two rows X 0.2m between rows spacing. The trail was repeated in two sowing dates; November 25th and December 22 to have heat stress exposure at different growth stage of the plants. Standard cultural practices for wheat production under such hot dry environment were followed. Data were collected on: canopy temperature depression, day to heading, maturity, chlorophyll content, photosynthetic efficiency, tillers, plant height and leaf areas. Currently, the material is at harvesting stage. Data on grain yield and yield component will be added. DNA was extracted from the RILs and parents and Dart molecular markers were developed. Field phenotypic and molecular data will be combined to map important traits for good performance under hot dry environment in these materials. A comprehensive genetic map for adaption genes in these materials for hot dry environment is expected to be generated and published.
b. Crossing materials consisting of 47 different lines of synthetic wheat and 5 Sudanese wheat varieties are grown in the field. The synthetic wheat lines were developed by crossing *T. Langdon* with different accessions of *Ae. Taushii* accessions. The Sudanese wheat varieties were of different flowering time to, at least, get one of them matches in flowering with the synthetics to enable crossing. Crossing between these synthetic and one or two Sudanese wheat varieties will be followed by 2-3 backcrosses to generate multiple synthetic populations in farmer preferred varieties to be evaluated and deployed in stressed environment. The process will be accelerated with molecular marker and doubled haploid technologies.
c. Twenty-four wheat genotypes were evaluated across four locations in a replicated trail with four replications in Sudan. The four sites were distributed along temperature gradient ranging from very hot, hot, intermediate and cool temperature from central to northern Sudan. Grain sample of about 50 gm from each plot separately were brought to bread making quality

analysis in Japan. Total gluten was extracted from representative samples from the extreme two trails to evaluate variation in gluten subunits due to temperature across the 24 genotypes using 2-dimentional PAGE separation. Protein extraction is completed and will proceed to the electrophoresis. Other quality related parameters will be measured in the remaining of the samples after complete of the 2-dimentionnal analysis. The outcome of this experiment will be useful in improving breeding strategies for improvement of quality of wheat varieties under hot dry environment.

Despite the work is still in progress, however, the expected results are:

a. Genetic map for useful traits in the alien materials for marker assisted introgression to enhance adaptation of wheat to hot dry environment.
b. Multiple synthetic wheat populations in farmer's preferred varieties for deployment in hot dry environment.
c. Understanding the nature of genetic variability of bread making quality of wheat under hot dry environment and genotypes variation for breeding of wheat with better quality in these harsh environments.

Besides the above presented experiments, the following activities were performed during the 6 months:

a. Participation in an international conference in Konia, Turkey during December jointly organized by Tottori University and ICARDA and presented a poster entitled "Overview of wheat improvement under hot dry environment of Sudan".
b. I had two business trips to Sudan in December-January and February-March to follow up the wheat trails conducted over there and initiate discussion over collaboration between ALRC and the relevant institutions in Sudan including the Agricultural Research Corporation.
c. Contribute in lectures to MSc students and participate in regular seminars in the molecular breeding lab.

References

Garg, M., H. Tanaka, and H. Tsujimoto (2009). Exploration of Triticeae seed storage proteins for improvement of bread end-product quality. *Breeding Science* 59:519-528.

Subbarao, G.V., T. Ban, M. Kishii, O. Ito, H. Samejima, H. Y. Wang, S. J. Pearse, S. Gopalakrishnan, K. Nakahara, Z. Hossain, H. Tsujimoto and W.L. Berry (2007). Can biological nitrification inhibition (BNI) genes from perennial *Leymus racemosus* (Triticeae) combat nitrification in wheat farming? *Plant and Soil* 299:55-64.

Sohail, Q., T. Inoue, H. Tanaka and H. Tsujimoto (2010). Expression of drought-related traits of *Aegilops tauschii* accessions and corresponding synthetic hexaploid wheats. Proceedings of this symposium.

Wang, S., L. Yin, H. Tanaka, K. Tanaka and H. Tsujimoto (2010). Identification of wheat alien chromosome addition lines for breeding wheat with high phosphorus efficiency. Breeding Science 60: 371-379.

(4) Project Researchers

Yasunori Kurosaki (Dr., Dust Climatology)

The Dust Climatology Subdivision has two subjects: (1) monitoring of the spatial and temporal dust distribution; (2) clarification of the relationship among wind, land surface conditions (e.g., soil size distribution, soil moisture, soil freezing, vegetation distribution, cultivation, grazing), and dust emission.

On the subject (1), the researcher has maintained the dust monitoring system built up in 2008, in which near-real time dust distribution is displayed every day mainly using MODIS true color images and present weather data contained in WMO SYNOP report. The images on the system are open on his homepage, and these are utilized for observations and discussion on dust emission and transport by students and researchers of universities and institutes.

On the subject (2), two papers were published. Major results are (a) The rise in dust emission frequency in desert regions could be largely attributed to an increase in the frequency of strong winds (i.e., erosivity); (b) For grasslands and croplands, however, he tied the increase in frequent dust emissions to a change in erodibility from results of threshold wind speed. This result means that the soil and land surface conditions had somehow changed; (c) Changes in the ground cover provided by dead leaves in the spring could be the driving factor in some parts of grasslands Mongolia.

Research grants in the fiscal year include:

Clarification of the relationship between land surface conditions and threshold wind speeds of dust emission for the evaluation of wind erosion in broad area

Japan Society for the Promotion of Science, Grant-in-Aid for Young Scientists (B), 2009-2012 (Project Leader: Y. Kurosaki)

Yunxiang Cheng (Dr., Plant Ecology)

The Plant Ecology conducts research on understanding and predicting the main drivers of plant community composition and species richness in arid and semi-arid lands. Especially, it is important to clarify the interaction between plant communities and environmental condition. Droughts frequency have become increasing in these years, particularly in Mongolia. Evaluating the impact of the drought to plant communities is important not only for comprehending the relationship between vegetation and dust emission, but also for overall ecological correctness. The main research topics in the fiscal year were as follows:

- Relationship between the dust emission and vegetation in grazing grassland of Mongolia
- Interannual changes in satellite-estimated vegetation around water points in Great Gobi A Strictly Protected Area, Mongolia

The main fellowship grants were the discretion from the Institutional Program for Young Researcher Overseas Visits.

Lijian Han (Dr., Conservation Informatics)

Two researches were carried out during Apr. 2011 – Mar. 2012. Detail follows:

1. Spatial variations in snow cover and seasonally frozen ground over northern China and Mongolia, 1988−2010

This study investigates the spatiotemporal variability of snow cover and seasonally frozen ground in northern China and Mongolia during 1988-2010 with passive microwave remote sensing records. We used the Goodison snow algorithm, adapted by introducing an additional soil freeze/thaw indictor to improve its efficiency in mountainous areas, and soil freeze-thaw algorithm to estimate snow cover onset, duration, ablation and, for the first time, the interval between snow cover ablation and the thawing of seasonally

frozen ground. Snow cover onset, duration, and ablation tended to vary systematically from high to low latitudes, and to trend toward early/long/late in elevated areas. The ablation-thawing interval varied from low- to high-latitudes/elevations, and from dry to relatively humid areas, being shorter (<2 weeks) in the north and elevated areas but longer in some cold-dry and plain-mountain adjacent regions. During 1988–2010, snow cover showed an earlier/later trend of the ablation/onset on the western Tibetan Plateau and a belt from northeast China to central Mongolia, with trends being stronger in spring than in autumn. The time of snow cover ablation was negatively correlated with maximum temperature in the northern study area, indicating that temperature mainly advanced snow melting in spring. However, no significant relationship between temperature and the interval was observed, suggesting that other unknown factors impact the interval. Furthermore, in the north and on Mt. Changbai the interval changed by <2 weeks, whereas changes were larger in cold-dry and plain-mountain transitional areas, indicating severe changes of Earth surface systems in those areas

2. An Enhanced Dust Index (EDI) for Asian dust detection with MODIS images

An Enhanced Dust Index (EDI) for MODIS solar reflectance bands is proposed that provides a means to detect the dust status of the atmosphere. The EDI utilizes only solar reflectance channels and may therefore be applied consistently to the entire MODIS time series records (1999 to present) for daytime dust observation, producing a higher spatial resolution (500 m) dust result than that from thermal infrared records (1000 m), which were developed previously and are currently being used. The index introduces dust optical density (α), which can be simply estimated by linear spectral unmixing, into the normalized difference between reflectance at near-infrared (2.13 μm) and blue (0.469 μm). Dust severity can thus be rated from weak to severe within a standard range of −1 to 1. The index was applied to 11 typical dust events during 2000–2010 in East Asia, where it showed good coherence with meteorological station-observed visibility (R^2 = 0.7909) and standardized visibility (R^2 = 0.7128). Further comparison with the commonly used Normalized Difference Dust Index (NDDI) and Brightness Temperature Difference (BTD) between MODIS bands 31 and 32 also indicated a better performance of the EDI in identifying the spatial and density distributions of dust. Previously applied satellite-based dust indices, particularly for the visible and near-infrared, can therefore be improved for a better quantification of dust aerosols.

Hisashi Tomemori (Dr., Protected Cultivation)

We conduct research on the sustainable cultivation method in the dry lands. Particular efforts are being made to improve the method of cultivation of physic nut (*Jatropha curcas* L.) which is the representative biodiesel fuel plant in dry land.

The main research topics in the fiscal year were as follows:

- Study on the irrigating method for the root systems of physic nut
- Low-temperature tolerance of physic nut
- Pruning method for physic nut
- Salt tolerance of physic nut
- Development and characterization of drought-stress tolerant plants using genetically engineering and arid-land simulator system

Overseas research activities during the fiscal year include visits to the National Institute for Investigation in Forestry, Agriculture and Animal Production (INIFAP) of Ministry of Agriculture, Animal Production, Rural development, Fishery and Alimentation, Mexico, for studies on salt tolerance of physic nut.

Tomoe Inoue (Dr., Crop Physiology)

Wheat suffers severe terminal drought and heat stresses in the dry Mediterranean climate regions. For agronomic and genetic improvement in wheat production in those regions, characterization on physiological mechanisms in drought and heat tolerant wheat genotypes is essential. In the fiscal 2011, I studied on photosynthetic characteristics of drought tolerant wheat cultivar under terminal drought and high soil temperature conditions.

I also have conducted joint research on root hemi-parasitic weed *Striga hermonthica*, the most serious biotic constrains on crop production in the dry areas of Africa, with researchers at Sudan University of Science and Technology. In the fiscal 2011, to clarify the mechanisms regulating water and solutes uptake of *S. hermonthica* from host plants, photosynthetic capacity and stomatal response in *S. hermonthica* and its sorghum host were investigated under different water regimes. Effects of endo/exogenous abscisic acid on stomatal response in *S. hermonthica* and sorghum were also evaluated.

Overseas activities during the fiscal 2011 were included; visit to the Sudan University of Science and Technology to conduct joint research on *S. hermonthica*; and participation in the international workshop held in Konya, Turkey.

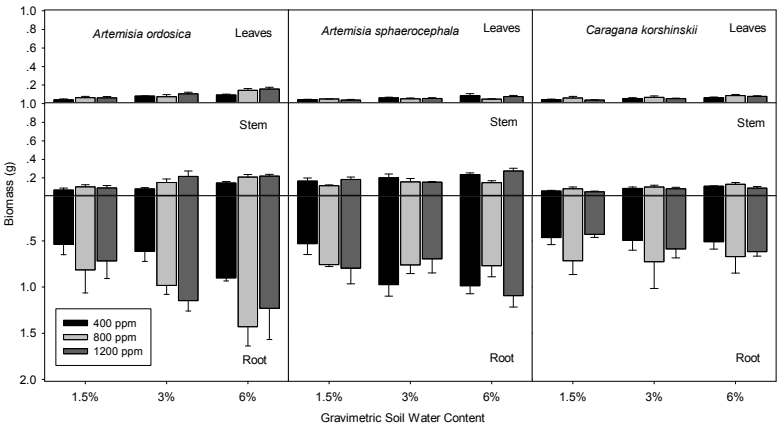
Zheng Mingqing (Dr., Restoration Ecology)

The research activities of the fiscal year are mainly focused on "Effects of climate change on vegetation growth in semi-arid land and their relevance to revegetation in desertified region". Mu Us sandy land is one of the center of desertification in northern China where the situation is getting worse in recent years. It is confirmed that mean annual temperature of Inner Mongolia has significantly increased over the past decades, with 0.4 ℃ per decade; and annual precipitation trends show a decrease in the east and increase in the west, which consequently changed the soil water content then impact plant growth of the local region. Therefore, especially efforts conducted in the growth chambers of ALRC were being made to profile the following issues:

(1) Growth rate and survivorship of drought: elevated CO_2 effects on the hypothetic tradeoff in dominant shrub species of the Mu Us sandy land in central Inner Mongolia;

(2) Water relations and photosynthesis adaptation of shrub species under predicted stress climate trends.

It has been identified that elevated CO_2 induced plant production through direct photosynthetic enhancements due to CO_2 enrichment or an increase in the amount of photosynthate available for the development of resource acquisition structures. Under morphological responses, plants can increase biomass allocation to the roots to



increase water uptake, and shed leaves to reduce the water requirements and maintain high water potentials. For species used in this experiment, especially in their seedling stage, CO_2 induced increases in root system more than above ground biomass or leaf area production(see the figure), which might increase soil exploration and water acquisition by these plants, then mitigate the effect of water deficit and enhance their survival in arid and semi-arid environments.

Fumiko Iwanaga (Dr., Tree Physiological Ecology)

Studies on eco-physiological characteristics of plant species growing in arid area are performed to clarify the mechanism of salt and drought tolerance, and to develop stress tolerance of planting species. In general, plant species would accumulate various metabolites such as betaines, sugars, and amino acids in response to abiotic stresses. The research deals with relationships between the amounts of accumulated these metabolites and characteristics of individual distribution and growth pattern of plant species in arid area.

In this fiscal year, investigations are carried out with herbaceous and woody species growing under drought and/or saline condition in the western U.S., including *Tamarix sp.* and three Chenopodiaceae species; *Atriplex, Lycium,* and *Allenrolfea*, to clarify the difference between native and non-native species .

Kingsley Chinyere Uzoma (Dr., Soil management)

Research Topics:

Development of biochar based slow release fertilizer for poor soils.

Assessment of biochar technology as a carrier for fertilizer to maximize fertilizer use efficiency

Rationale:

There is already strong evidence that biochar can increase nutrient retention and N use efficiency in sandy soils, reduces leaching of N through soil and reduces greenhouse gases emission in some circumstances. The research would further develop a product based on biochar as a carrier for fertilizer. Soils in Nigeria and other sub-Saharan African countries are typically poor in organic matter, made worse by the lack of economical fertilizer. Therefore, this research will address the socio-technical opportunities and challenges of the development of a biochar technology as a carrier for fertilizer to improve soil fertility and maximize fertilizer use efficiency in Nigeria. It would also investigate the beneficial reuse of farm waste biomass into biochar (with an aim here being sourcing cheap/ waste sources of N fertilizer).

Methodology:

The research initiative will be organized into three closely linked streams of research activities: (1) **biomass pyrolysis and biochar slow release fertilizer production**, (2) **soil science and biochar** by focusing on the fundamental aspects of biochar produced slow release fertilizer behaviour in soils and (3) **socio-technical survey and assessment of biochar technology in Nigeria** as a carrier for fertilizer to maximize fertilizer use efficiency, which will be supported by my close collaborative ties to Federal University of Technology Owerri, Nigeria, and strong extension activities with local farmers and project-led field demonstrations.

Expected results and impacts

The expect results from this study will include the clarification of the effectiveness of biochar produced slow release fertilizer in improving soil nutrient retention and the longevity effect of biochar produced slow release fertilizer in retaining soil nutrients. It will also highlight the socio-economic

efficiency associated with using biochar as the slow release carrier for mineral fertilizers, and consequently serve as a source of technical incentive to farmers to adopt biochar based slow release fertilizer in their farm planning.

Abdelmoneim Abdelsalam Mohamed (Dr., Climatology)

Developing an index based on surface temperature for assessment of moisture availability over vegetated land.

Andry Henintsoa Ravolonantenaina (Dr., JSPS Postdoctoral Fellow)

Soil, water and nutrients are the basic resources in agriculture for food and environmental security. The rapid decline in quality and quantity of global natural resources due to degradation and uncontrolled resource consumption in many countries, especially the developing countries is a threat to sustainable agriculture and environmental security. Adoption of a more holistic approach with a strong focus on the integration of soil-plant-water-nutrient by maintaining an appropriate balance between the use and conservation of soil nutrients and water resources for sustainable agricultural and environmental security is a new challenge.

Water and Land Management Subdivision conducts research on the maintaining of a proper supply of organic matter in the soil, a proper nutrient and water supplies, and also controlling of soil pollution and erosion in dry land regions. Improved agricultural practices have great potential to increase the amount of carbon sequestered and water retention in cropland soils. By the adoption of this management practice, agriculture contributes not only to soil conservation and water quality goals, but also for enhancing the amount of soil organic carbon in the soil and to mitigating carbon dioxide (CO_2) emission effects on climate change. The main research topics in the fiscal year were as follows:

- Clarifying the effectiveness of organic matter content derived from organic waste materials on soil aggregate stability, soil hydraulic properties, and nutrients availability in sulfate acid soil.
- Determining the effect of two hydrophilic polymers derived from industrial wastes on the water holding capacity and hydraulic conductivity of sandy soil, as affected by soil temperature and water quality.

Mohamed Abd Elbasit Mohamed Ahmed (Dr., JSPS Postdoctoral Fellow)

Relationship between rainfall erosivity indices in Liudaogou basin, Loess Plateau, China

Background:

The arid and semi-arid regions suffer a scarcity of rainfall information with reasonable time and space resolution. Under these conditions, the availability of reliable data for rainfall erosivity evaluation can works as limiting factor for better understanding of soil erosion and assessment of land degradation and conservation in such areas.

R- factor in the Universal Soil Loss Equation (USLE) and its revised and modified versions represents the major rainfall erosivity, which can be defined as the product of total kinetic energy of storm times its 30 min maximum intensity(EI_{30}). The rainfall erosivity, similar to other rainfall properties, is controlled by the rainfall drop size distribution (DSD). Because the rainfall DSD is qualitative rainfall information, various indices have been developed to quantify the rainfall erosivity. Rainfall kinetic energy (KE) is the major index that has been used by several researchers in order to quantify the rainfall erosivity under natural

rainfall. Also, several I-KE relationships can be applied depending on the location and dominant type of rainfall. The objectives of this study are to: (1) evaluate various indices for rainfall erosivity estimation in Loess Plateau, China environment; (2) and develop relationships between rainfall erosivity indices calculated from rainfall data with different temporal resolution

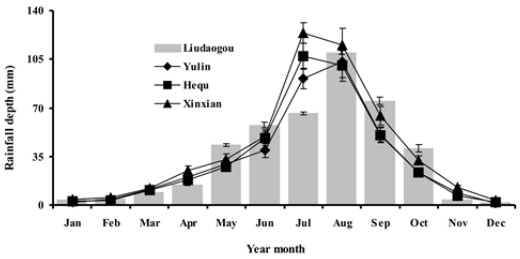
Methodology:

The rainfall was measured using three tipping-bucket rain gauges (Davies rain collector II, CA, USA) with 0.2 mm depth resolution. The rain gauge was attached to an event data logger (HOBO Event Logger, Onset Computer Corp., MA, USA) with 0.5 s interval recording accuracy. The rain gauge has been installed in the study area for the period from August, 2004 to May, 2009. Non-liner regression analysis was used to generate relationships between monthly rainfall, monthly Fournier index, annual rainfall, and Modified Fournier Index from one side and R-factor calculated from the detailed measurement for the rainfall during the observation period on the other side.

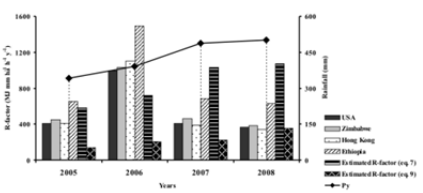
Results:

The short period observation of rainfall was compared with the long term observations of rainfall data obtained from three closest rainfall station, namely Yulin, Hequ, and Xinxian. The four stations showed similar pattern of monthly rainfall depth. The rainy months for the four stations layed on the period from May to October, and approximately 24% of the rainfall occurred in August. Moreover, above 85% of rainfall in the four stations occurred during the rainy months, which indicate that high amount of rainfall concentrated in short period. The average annual rainfall for the three stations was 422.25 mm compared to 430.85 mm in Liudaogou. The Modified Fournier Index (MFI) was 76.46, 89.04, 96.31, and 85.07 in Liudaogou, Hequ, Xinxian, and Yulin, respectively. The variation in MFI for the four stations was less that 10%, which indicate that the rainfall monthly distribution during the recent 40 years.

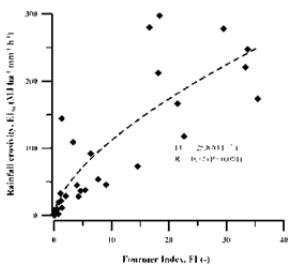
Generally, rainfall erosivity indices can be classified into rainfall macro-structural indices and micro-structural indices. The macro-structural indices follow the rainfall depth and on the other hand the micro-structural indices are ultimately sensitive to rainfall intensity and energy content. The micro-structural rainfall erosivity indices should perform better in soil erosion estimation, specifically splash and interrill soil erosion. However, the data availability can be considered as major limitation of using this type of indices. In this study, EI_{30} was considered as micro-structural erosivity index on one hand, and Fourier Index (FI), modified Fourier Index (MFI), and half month erosivity index as macro-structural rainfall erosivity on the other hand. Due to scarcity of rainfall records in arid areas Thus, development of relationship between micro- and macro-structural rainfall erosivity indices will be useful for rainfall erosivity evaluation under data scarcity condition. Based on the results of this study, the EI_{30} can be significantly estimated from the FI and P_i data using simple power relationship ($R^2 = 0.77$, $P<0.001$). However, the existence of high erosive rainfall events suggested that the incorporation of the maximum rainfall intensity in the relationship may enhance the relationship performance.



Monthly pattern of rainfall erosivity



Annual rainfall pattern



Relationship between EI_{30} and FI

Relationship between rainfall erosivity indices under Liudaogou basin in Loess Plateau, China

Background:

Rainfall simulators are mainly developed to imitate natural rainfall in its various properties. The rainfall properties including rainfall rate and energy are one of the important parameters for determining the rainfall erosivity. Rainfall erosivity is defined as the potential of rain to cause erosion (Epema and Riezebos, 1983). Several indices have been suggested to quantify the rainfall erosivity (Abd Elbasit et al., 2010). Generally, the suitable erosivity index must include the drop mass and velocity as major variables for raindrop power determination. The erosivity index has been described by Epema and Riezebos, 1983 as follows:

$$E \propto m^{\alpha} v^{\beta}$$

(1)where m is drop mass in (kg); v is fall-velocity (m s^{-1}); α and β are coefficients

Under simulated rainfall, the simulator height is another factor which may affect simulated raindrop velocity. Small raindrops (<0.03 mm), generally, need only very short distance to reach terminal velocity. On the other hand, raindrops with few millimeters in size require above 10 m to reach their terminal velocity (Wang and Pruppacher, 1977). The objective of this study is to assess various raindrop fall-velocity relationships in order to estimate simulated rainfall kinetic energy under dripper type rainfall simulators.

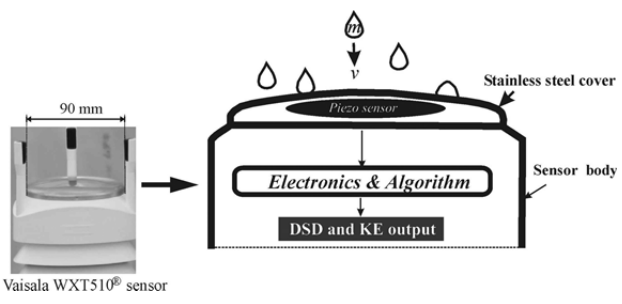
Methodology:

Dripper-type rainfall simulator located at the Central Arid Research Dome of the Arid Land Research Center, Tottori University, Japan was used to simulate rainfall events with rates range from 1.2 to 27.6 mm h^{-1}. The simulator consisted of 12.5 m height steel frame. The rainfall drop size distribution (DSD, mm) and kinetic energy (KE, mJ) were measured using piezoelectric sensors. Both sensors were modified from Vaisala RAINCAP® rain sensor. The measurement principle of sensor is based on the acoustic detection of individual raindrop impact. The drop impact generates acoustic waves at the piezoelectric detector.

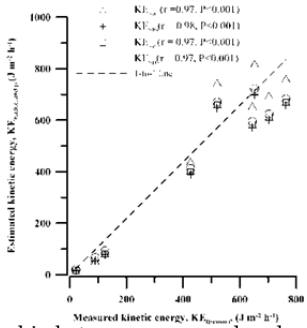
Results:

This study examined various published relationships to estimate the raindrop fall-velocity under simulated rainfall. The fall velocities calculated from these relationships were compared with average fall-velocity calculated from rainfall kinetic energy and drop size distribution. The results showed significant associations between estimated fall velocities and average rainfall-velocity. The estimated raindrop fall-velocities were used to estimate the rainfall kinetic energy using the drop size distribution measurement under rainfall intensities ranging from 1.2 to 27.6 mm h^{-1}. The estimated kinetic energy showed high correlation with measured kinetic energy using the KE sensor.

Also, new raindrop fall-velocity relationship was developed using published data set. The advantage of this relationship is that it gives the raindrop fall-velocity as function of drop size and fall height. Moreover, the calculated kinetic energy using this relationship was highly correlated with measured kinetic energy using the KE sensor. However, the use of proposed relationship is valid only in the range of calibrated intensity.



Piezoelectric transducer used for KE measurement



Relationship between measured and estimated KE

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(April 2011 – March 2012)
Title: Ecosystem Modeling for a Temperate Grassland Wind-Erosion Scheme

Current existing dust models do not have sufficient capability in simulating vegetation growth and decay effects that play a major role in temperate grassland (TG) aeolian processes. In this research, the objectives were (i) to develop of an ecosystem model by analyzing the mechanisms of vegetation/soil moisture and aeolian processes in TGs, and (ii) to incorporate a developed ecosystem model into an integrated wind-erosion scheme. In here, brief descriptions of our research studies are given.

1. *Model parameterizations, simulations and validations of an ecosystem model*: We assessed the grassland ecosystem model (DAYCENT, most prominent biogeochemical model) for its capability to provide estimations of the realistic land-surface conditions (such as vegetation and soil moisture) in the Mongolian TG under different grazing conditions. The DAYCENT was parameterized with the field experiment data (soil properties, vegetation and grazing) and validated against a set of 8-years (2003−2010) field data. Generally, the model was performed reasonably well in vegetation (growth-decay), soil moisture dynamics, and their memories, and also the effect of grazing on grasslands. These parameters are the factors controlling dust outbreaks in TGs. Moreover, the simulated land surface parameters were used to analyze the relationships between dust emission and land surface parameters. Therefore, this model will provide a useful tool for dust emission study in TGs.

2.*Incorporation of developed ecosystem into an integrated wind-erosion scheme*: Presently, we are in the process of incorporating the DAYCENT model (Fig. 1) into an integrated wind-erosion scheme "QF2003" (Shao et al., 2004). This coupled "DAYCENT-QF2003" modeling system allows examination of the feedbacks between grassland-grazing and Aeolian processes under the following scenarios: (i) grazing (heavy, moderate, and light) and (ii) climate change (strong global warming, no global warming, and global cooling). We are expecting to get the following reliable results at the end of this research: (i) developing a TG land wind-erosion scheme (new approach) which will provide a useful tool for early warning system and future projection of dust events, and (ii) providing important knowledge for implementing a dust management over TG dust source areas.