# 1. Research Activities (Apr. 2010-Mar. 2011)

## 1.1 Outline of Research Activities

### (1) 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 had undertaken the 21st COE Program "Program for Arid Land Science" for five years, terminated in March 2007. The 21st COE Program had contributed to promoting arid land science, development of human resources that made young scientists more creative and lead their scientific field, and establishing international networks of arid land science and education. For further development of the achievements of the last 21st COE Program, Tottori University applied the Global COE Program "Global Center of Excellence for Dryland Science" to the Ministry of Education, Culture, Sports, Science and Technology in 2007, and it was adopted.

The aim of this program is to construct the new arid land science that is unparalleled worldwide. The ALRC (including the predecessor) have accumulated knowledge and technology of plant production and vegetation recovery in sands. We are advancing this knowledge and technology to those that are used easily for the arid lands on the world. To achieve our goal, we fuse knowledge and technology of public health. The mission of this program is to contribute towards environmental sustainability through development of technical package that will be easily adopted by arid land inhabitants. Achievement of this objective forms 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 started the Core University Program (by JSPS) focusing on combating desertification and developmental utilization in inner area of China between Arid Land Research Center, Tottori University and Water and Soil Conservation Research Institute, CAS in China in FY 2001 and accomplished in FY 2010.

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

FY2010 was 20$^{th}$ year since we started as Arid Land Research Center on June 8$^{th}$, 1990 as a successor of the Sand Dune Research Institute under the Faculty of Agriculture of Tottori University. We celebrated its 20$^{th}$ year of anniversary and also published anniversary booklet. International Arid Lab has been built this year and this new lab will enhance the Center's aspiration to become and maintain its center of excellence for drylands studies in the world.

### 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.

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 four professors, six associate professors and four assistant professors. The other division has one associate professor. The all division has one visiting professor and two associate 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 a research support technician support the research and education.

**Joint-Use Research, Education, Publication**

During the fiscal year of 2010, 70 Joint-Use Researchers (Teachers from national and private universities) were attached to the Center. The number of students as of October 2010 is 24 (14 Ph.D. Students, 8 Master Students, 1 Undergraduate Students, 1 Research Students).

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 4, 2010 at Arid Land Research Center, Tottori University.

On September 13-14, 2010, Core University Program 'CAS-JSPS Core University Program Japan-China joint open seminar on combating desertification and development in inland China of year 2010' was held in Tottori, Japan.

## (2) Divisions

### 1) Division of Climatology and Water Resources

**Prof. Masato Shinoda (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)
(2) Climate memory dynamics of terrestrial ecosystems over the Asian-African arid region
(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)

**Assoc. Prof. Reiji Kimura (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 conducting under the aid by Japan Society of the Promotion of Science Grants (KAKENHI 20405038, 21404007, and 20255001) and JAXA Global Observation Mission, especially in China and Mongolia.

**Assoc. Prof. Hiroshi Yasuda (Hydrology)**

The Hydrology Subdivision carries out research on the monitoring and modeling of hydrological phenomena in the dry environments. In the fiscal year research activities covered China, Egypt and Sudan. In China groundwater and soil water movement in a small watershed (dam farmland) of the Loess Plateau was observed and analyzed as activities on project of the Global COE and Core University. The result showed that water uptake by plants was pronounced except the evaporation. As limited water resources in the arid environment, groundwater has an important role on plants growing. On behalf of the international cooperation project of the EU, water movement through the vadose zone in Sinai, Egypt was analyzed. As a new project, study on relationship between mesquite and groundwater in Sudan has started in this fiscal year.

**New project in Sudan.**
Interaction between vegetation ecology and sub-surface hydrology is studied in Sudan.

**2) Division of Biological Production**

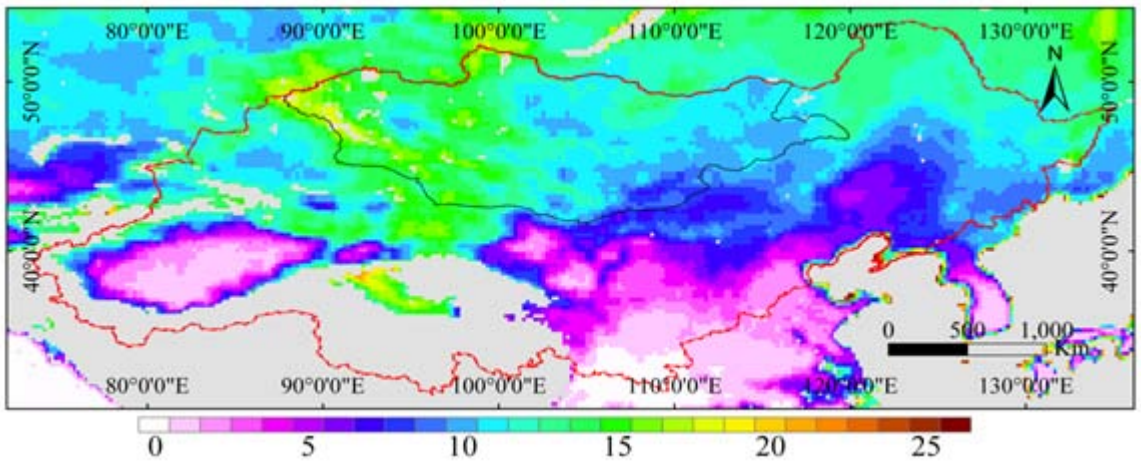
**Prof. Atsushi Tsunekawa (Conservation Informatics)**

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 Center's facilities. The main research topics in the fiscal year 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 include visits to the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria to carry joint research and capacity building activities from October 28 to November 4, 2010. I participated in the meeting held at the Institute of Soil and Water Conservation, Yangling and the Cold and Arid Regions Environment and Engineering Research

Institute (CAREERI), Lanzhou, both belonging to Chinese Academy of Sciences in China from January 17 to 23, 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.

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

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

- Drought tolerance and its mechanisms of wheat
- 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 of Mu Us sandy land in China

Overseas research activities during the fiscal year include visits to Northeast Agricultural University in China for giving a key-note speech in an international symposium on Renewable Energy and Arid Land Science, and to Center for Agricultural Resources Research of the Chinese Academy of Science for the cooperative study on Halophytes Utilization in Bohai Bay in China.

**Assoc. Prof. Mitsuru Tsubo (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 modelling, and also field work and indoor experiment are conducted to build and test plant growth and production models. The current research topics are:

- Analysing plant response to drought
- Modelling plant production in drylands

- Developing a drought early warning system

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

- Development of an integrated drought early warning system for dry grassland in South Africa
- Survey on impacts of rainfall variability and grazing pressure on vegetation in Mongolia

Typical grazing grassland in South Africa

**Assist. Prof. Wataru Tsuji (Crop Eco-physiology)**

The Crop Eco-physiology Subdivision has conducted research on the elucidation of eco-physiological characteristics of crops, and development of appropriate cultivation technology in arid land. Particular efforts are being made to clarify the response to environmental stress and its resistance mechanism in crops, to develop cultivation technology for enhancement of water use efficiency (WUE) and mitigation of drought stress in dryland agriculture with combining the basic research in Japan using the Center's facilities and applied research at real dryland fields.

The research themes in the fiscal year were as follows;

- Influences of defoliation on WUE and grain yield in sorghum under drought stress.
- Effects of seed-hardening on wheat cultivation under drought stress.
- Clarification of eco-physiological characteristics of bio-diesel plants (*Jatropha* and *Pongamia*), and development of its low input cultivation technology.

Overseas research activities during the fiscal year included visits to Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences for seminar and discussion on cooperative research, and to ICARDA (Syria) for field trial.

**Assist. Prof. Takehiko Ito (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.

A goitered gazelle in Great Gobi A Strictly Protected Area, Mongolia

In the fiscal year, we surveyed environmental factors such as vegetation in Mongolian Gobi, and analyzed relationships between movements of wild ungulates and environmental factors. 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. We also conducted researches on the endangered saiga antelope in Kazakhstan and Uzbekistan.

Overseas research activities during the fiscal year include field researches in Mongolia, Kazakhstan, and Uzbekistan, and attending conferences in Mongolia.

**3) Division of Afforestation and Land Conservation**

**Prof. Mitsuhiro Inoue (Land Conservation)**

The land conservation subdivision conducts research on the reduction of soil degradation (soil erosion and salt accumulation), and suitable soil management for sustainable agriculture in arid regions. Several efforts are being made to proffer the development of technology on a desirable land conservation that is required to prevent soil degradation in dry lands. 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 sub-surface drip irrigation, (4) Development of labor-saving and water-saving irrigation using recycled products, (5) Determination of soil physical properties in arid regions.

In this fiscal year, my group has one doctoral student (Kingsley C. Uzoma) and six master's students under my direct supervisor. I collaborated with fifteen joint researchers, a postdoctoral researcher (Shigeoki, Moritani) and a visiting researcher (Zahoor Ahmad) from Pakistan. Mr. Masayasu Okazaki (master course first grade) participated in the International Training Program supported by JSPS and studied in Tunisia. Four students (Ryosuke Makino, Hirokazu Sakai, Shinichi Kubota and Miki Fukushima) obtained Master's degree in March, 2010 and got their jobs.

Overseas research activities during the fiscal year include three times visiting the Republic of Kenya and the Kingdom of Morocco supported by National Federation of Small Business Association (water-saving vegetable cultivation in arid regions) and China supported by Core-University Program. The result was presented in the ASA-CSSA-SSSA 2010 International Annual Meetings in Long Beach (USA) in October 2010. As the president of Japanese Society of Soil Physics, I organized the 2010 Annual Meeting of Soil Physics in Tottori and also conducted a poster presentation. I had a chance of open lectures on the 2010 Tottori University Frontiers of Knowledge entitled 'Ultimate water-saving irrigation using recycled products in sandy soil', three times at Tottori, Kurayoshi and Yonago. The Chugoku and Shikoku branch of Japanese Society of Irrigation, Drainage and Rural Engineering gave the encouraging award to Makino, Inoue, and Nagaz for the original paper 'Comparison and evaluation on efficiency and sustainability of surface or sub-surface drip irrigation in southern Tunisia'. A patent for the irrigation device, irrigation system, and irrigation method was applied in Oct. 2010, supported by Industry and University Cooperation Office, Tottori University.

**Prof. Norikazu Yamanaka (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

Field survey on Halophytes around Aral Sea, Uzbekistan

As the overseas activities of the fiscal year, the research on ecosystem restoration was carried out in the

Loess Plateau of China in April 2010 and January 2011. In Jul. 2010, the collaborative research on Halophytes was carried out around Aral Sea with Science Academy of Uzbekistan. Collaborative research on Halophytes in Xinjiang province was carried out with Xinjiang Agricultural University in Aug. 2010. Another collaborative research on Halophytes was also conducted in Ningxia province with Chinese academy of Science and Kyushu University in Sep.2010.

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 Center. Field survey on Osmoregulation of Mangrove trees was also conducted with Ryukyu University.

In 23 Oct. 2010, Prof. Yamanaka participated the UNCC's Land day3 'The Nexus Between Biodiversity and Desertification' held at Nagoya and coordinated the Panel Session 3 'How can scientists contribute to biodiversity conservation in the drylands of Eastern and Central Asia?'

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.

Japan Society of the Promotion of Science Grants-in-Aid for Scientific Research (B), 2009-2012 (Project Leader: N.Yamanaka)

**Assoc. Prof. Haruyuki Fujimaki (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 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
3) Grants-in-Aid for Scientific Research "Development of advanced water use cropping system utilizing water vapor in soil in dryland"

Regarding to 1, 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 canola) were mainly carried out. Measurements of soil hydraulic and thermal properties for the observation site were main activities for 3.

Moisture and salinity probes inserted into the root zone of Jojoba

Overseas research activities during the fiscal year were:

1)visits to Egypt for "Sustainable systems for food and bio-energy production with water-saving irrigation in the Egyptian Nile basin" for 123 days in total in 5-times,

2) oral presentation in 19th World Congress of Soil Science held in Australia

3) oral presentation in ASA-CSSA-SSSA 2010 International Annual Meetings in USA
4) retrieval of monitoring system for “Development of advanced water use cropping system utilizing water vapor in soil in dry season”

**Assist. Prof. Takeshi Taniguchi (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:

Arbuscular mycorrhizal fungi in *Sabina* root

- Distribution and community structure of microorganisms (mycorrhizal fungi, endophytic fungi and endophytic bacteria) in Tamarisk (*Tamarix ramosissima*) roots along the gradient of salt in Southwestern America.
- Vertical distribution of microorganisms (mycorrhizal fungi, endophytic fungi and endophytic bacteria) in *Sabina vulgaris* roots in Mu-su desert, China.
- How rapidly do the symbiotic microorganisms in roots response to water inputs?

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

**4) Division of Socioeconomics**

**Assoc. Prof. Takayuki Ando (Arid land development)**

The Socioeconomic Division conducts studies on the sustainable rural development system in arid lad using biofuel plants as part of 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 can be used to help to alleviate rural poverties and to improve their livelihood.

Main activities in fiscal year 2010 were:

(1) survey of current situation of *Jatropha* cultivation by small scale farmers in Mexico

In 2006, the Chiapas State Government made public the Bioenergy Programme of Chiapas; thereby multitiered support activities by diverse institutions to farmers have started. Surveys on the situation of *Jatropha* cultivation were conducted in Tierra Santa village where the farmers are


*Jatropha* and farmer

striving proactively.

(2) launching of the *Jatropha* Core collection project

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

Based on the Agreement, analysis of genetic diversity of *Jatropha curcas* using SSR (simple sequence repeat) markers was commenced by project members using 90 freeze dry samples provided by INIFAP.

**5) Division of Health and Medicine**

**Visiting Associate Prof. Shinji Otani (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 comprehensive measures against Asian dust in collaboration with other groups.

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

- Evaluation of Asian dust events on the daily symptoms of healthy subjects in Japan
- Assessment of nomadic health and vulnerability in Mongolia

Research grants in the fiscal year include:

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 include visit to Hospital of Bayan-Onjuul, Mongolia for health survey of nomads (photographs).

## (3) Foreign Researchers

**Dr. Elfadil Elfadl BABIKER (Plant Biochemistry)**

September 2009 – October 2010

Faculty of Agriculture, University of Khartoum, Sudan

Title: Fertilization and inoculation of winter sorghum: Morphological, physiological an biochemical characterization

**Summary of the research activity:**

The research to be carried out and the other academic activities including field experiments, laboratory work on sorghum fertility, conducting seminars, attending an International conferences, participation in workshops, attending seminars, checking of the students final thesis as well as colleagues manuscripts, reviewing of many papers for international journals around the world and establishment of scientific relationship between Tottori University and Khartoum University are considered carefully and given fulltime.

***A. Research activity:***

Background:

Sorghum (*Sorghum bicolor* L. Moench) is a drought resistant indigenous crop of Africa and as such plays a significant role in the food security of the rural populations of southern and eastern Africa. Sorghum is generally consumed as fermented flat bread (*Kisra*), thick porridge (*Asseda*), thin fermented gruel (*Nasha*), boiled grain (*Balela*) and non-alcoholic beverages (*Sharboat, Abreh and Hulomor*). Most of these indigenous foods are produced by traditional processes. Recently large efforts have been directed to improve the nutritional quality of cereal grains particularly to improve the level of essential amino acids as well as protein digestibility. Low productivity and nutritional quality of sorghum are a common problem encountered in all States in Sudan. Winter and summer sorghum are among the crops grown in rural areas for local consumption. The production of winter sorghum is very low compared to summer one. Improvement of the proteins quantity and quality will make sorghum a useful source of protein as well as other constituents. Since 1992 we have been involved in research related to developing countries' crops and foods with emphasis on crops that grown in far rural areas in which people are suffering from malnutrition due to low quality and quantity of products as a result of bad environmental and soil conditions. We started to improve the crops nutritional value either by substitute the food with other ingredients or improve the soil nutrients. The basic crops involved in our research are sorghum and millets. In far rural areas (Western and Northern Regions) desert is the key problem and farmers grow such crops in valleys of low water content. Therefore, the nutritive value of such crops is very low due to the following reasons:

1. Poor soil fertility.
2. Adverse climatic condition.
3. Farmers usually grow crops that can resist such adverse conditions which are known to be of low quality.
4. The presence of antinutrients in large quantities in such crops.

Currently we would like to utilize valleys and desert around valleys to increase the area of production (quantity) but quality wise we are now studying different approaches to solve this problem. The main approach now is to study the effect of micronutrients on nitrogen content and physiological and morphological characteristics of different sorghum cultivars.

**1. Pot Experiments:**

Two sorghum cultivars (Tabat and WadAhmed) were used in this investigation. The seeds were obtained from the Department of Agronomy, Faculty of Agriculture, University of Khartoum, Sudan. Three seeds are sown in each pot (0.05 $m^2$) in the green house and after germination are thinned to one plant per pot. Each cultivar immediately after sowing received four different levels (0, 2, 4 & 8 mg/pot) of compound micronutrients (14% water soluble Mg + 0.3% water soluble Mn + 0.3% water soluble B + 1.2%

FeS + 0.02% $Cu_2SO_4$ + 0.02% $ZnSO_4$ + 0.004% $(NH_4)_6[Mo_7O_{24}].4H_2O$) as well as 6mg/pot compound macronutrients (N-$P_2O_5$-$K_2O$, 16-16-16%). Four replicates for each treatment were planted. The pots were irrigated according to the weight difference of each pot. At maturity the plants are harvested and separated into two different parts; seeds and shoots for further analysis. The seeds and shoots of the cultivars were cleaned manually to remove broken seeds, dust and other extraneous materials. The cleaned grains and shoot were milled into fine flour to pass a 0.4 mm mesh size screen and stored at 4 $^oC$ before used for further analysis.

**2. Laboratory work:**

*Parameters to be measured:*

1. Physical characteristics of the seeds (color, shape, size) and shoot (leaf color, leaf size) of the plants.
2. Nitrogen content as well as protein content of the seeds and shoot of the plants.
3. Amino acid composition of the plants seeds and shoots.
4. Correlate the level of micronutrients with changes occurred for the parameters above.

**Results:**

Pot experiments:

It is clear that from the experiments done in the field, sorghum cultivars received micronutrients are better and significantly improved compared to the control (not treated with micronutrients) ones with respect to 100-seed weight, seed size, seed color, plant height, leaf area, leaves length, chlorophyll density.

**Laboratory work:**

Although the temperature was high (45±5$^oC$) throughout the growing season, sorghum treated with micronutrients contained high level of nitrogen in both seeds and shoots compared to that grown without application of micronutrients. The level of nitrogen in seeds and shoots increased with micronutrient dose. The results of the laboratory analysis showed that there are variations within and between cultivars in nitrogen content of both seeds and shoot and such variations are as a result of micronutrient application. Moreover, nitrogen content of both shoot and seeds of treatment received high dose of micronutrient (8mg/pot) exceeded that of sorghum grown under favorable conditions in Sudan as well as sorghum grown without micronutrient application. Amino acid composition of the treated samples will be determined to investigate the effect of micronutrients on seed and shoot composition.

**Seminars:**

The following open seminars were conducted during my stay at the Arid Land Research Center:

1. Application of Biotechnology to Food Crops in the Sudan: Needs, Opportunities and Barriers.
2. Cultivation of Soybean in Sudan: Effects of intercropping, inoculation and chicken manure fertilization.
3. Comments on Sorghum Grown in Sudan: Growing condition and utilization.
4. Cowpea as a Source of N to Rainfed Sorghum in Sudan.

***B. Other activities:***

1. Participation in the discussion of visiting researcher seminars as well as master and PhD students' seminars.

2. Reviewing and editing scientific manuscripts of graduate students and researchers for conference and publication as well as students PhD thesis.
3. Act as a reviewer for many International Journals during this period such as: International Food research Journal, African Journal of basic and Applied Sciences, Research Journal of Agriculture and Biological sciences, Australian Journal of Basic and Applied Sciences, World Applied Sciences Journal and African Journal of Food Science.
4. Visited Sudan to attend University of Khartoum conference entitled "The role of Scientific Research on nation's development" which held from February 27 to March 2, 2010. I have been awarded a prize as a distinguished researcher in the closing ceremony of the conference.
5. Visited Sudan to prepare a visiting program for a delegation from Tottori University to make a scientific relation with University of Khartoum from February 14 to March 4, 2010.
6. Visited Sudan with Tottori University delegation to sign a memorandum of understanding between Tottori University and University of Khartoum from March 27 to April 2, 2010.

**Dr. Jugder DULAM (Meteorology)**

April 2010 – March 2011
Institute of Meteorology and Hydrology, Mongolia
Title: Dust emission processes in Mongolia

**Summary of research activities:**

The section of the research report discussed my research activities including the local and regional seminars during 12 months from 1 April 2010. While I participated to the open seminars by researchers, who are working and inviting at the center and its laboratories, I made the open seminars 3 times at Arid Land Research Center (ALRC) and their titles are given below:

1. Dust storms in Mongolia on 13 July 2010
2. A new network for dust storm observations in Mongolia and its application on 28 September 2010
3. Collaborations and activities of NE Asian countries on Dust/Sand Storms on 21 February 2011

My contributions to the local seminars, meetings and symposiums associated with ALRC and its laboratories were four presentations consisting of three orals and a poster, and their titles are available from the following list:

1. A new network for observation of dust storms in Mongolia and application of new data, The Laboratory of Climatology, ALRC, 20 April 2010,
2. Dust storms and PM10 (PM2.5) concentrations in the Gobi Desert of Mongolia, The Meeting of the Global COE Program, 17 November 2010
3. PM10 (PM2.5) concentrations during dust storms in the Gobi Desert of Mongolia (Poster presentation), The Joint Research Symposium of the FY 2010 at ALRC, 4 December 2010.
4. Dust concentrations in the Gobi Desert of Mongolia, The Academic conference of the Chugoku-Shikoku Chapter of the Society of Agricultural Meteorology Japan, No.23, 16 December 2010, p. 40-41.

In addition, I had a presentation about the Mongolian life and culture at a High School of Tottori City on 8 December 2010.

An important activity during the one year period of the visiting researcher at the ALRC, Tottori University, is my attendance in the international workshops, meetings and seminars related with the NE

Asian regional cooperation in researches of the dry land processes. I had delivered the dust storm generation mechanisms and observed dust emissions. The titles of relevant presentations are:

1. D.Jugder, Disasters harmful for ecology in the eastern region of Mongolia, The International Workshop for the 2nd Amur-Okhotsk Consortium Meeting 2011, Sapporo, 1-2 November, 2010
2. D.Jugder, N.Otgonjargal and B.Munkbat, Analysis on meteorological elements and PM10 concentrations with the lidar measurements during a dust storm observed in Mongolia in 26–27 May 2008, The 3rd Meeting of Working Group (I) for Joint Research on DSS among Mongolia, China, Korea and Japan, Jeju, Korea, 8–10 November 2010.
3. D.Jugder, Climate change in Mongolia and their impacts on nomadic herder's life, A seminar on the Nomadic herder's life and ninja, Osaka University, 21-25 March 2011

It is essential to include a brief explanation of my study activities. 2010 was a year of progress and achievement for my research. I made studies dust emissions in the Gobi Desert of Mongolia and created new articles based on researches using data obtained from new measurements in dust source dry land areas. I have produced 3 articles at ALRC, Tottori University, Japan during 12 months from 1 April 2010 to 31 March 2011 that are with states including the printed (accepted), submitted and in preparation. An article is printed in the Journal of Scientific Online Letters on the Atmosphere (SOLA), Japan, the second article is submitted to the International Journal of Global and Planetary Change, and the third one is in preparation for the International Journal of Atmospheric Environment. The results of articles are given in detail in the section of "the research results".

**Title of articles:**

1. Printed article:

   Jugder Dulam and Masato Shinoda, 2011. Intensity of a Dust Storm in Mongolia during 2931 March 2007, SOLA, Vol. 7A (2011), Special Edition: Typical Asian Dust 2007, p.29-31, *(Manuscript received 26 October 2010, accepted 14 February 2011, printed 12 March 2011, SOLA: http://www. jstage. jst. go. jp/browse/sola/).*

2. Submitted 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, *Global and Planetary Change*.

3. The article in preparation:

   Jugder, D., N. Sugimoto, M.Shinoda, I. Matsui and M. Nishikawa, Dust storms, forest fire smoke and air pollution detected by polarization-sensitive Mie-Lidar measurements in Mongolia, *Atmospheric Environment*.

**Results of my research:**

*Result 1: Intensity of a dust storm in Mongolia during 29-31 March 2007.*

A dust storm occurred in the Gobi Desert and steppe-desert regions in 29-31 March 2007 was one of the severe dust episodes in NE Asia in this year. Due to the dust storm, a person died and 6 people were lost in Mongolia. About 30 communication and electric poles were damaged and communication services and electricity transports in some provinces were stopped for several days. Roofs of about 14 buildings were broken. Some sections of railway were enshrouded by sand accumulation. As well, the dust storm

reached to Korea and Japan passing trough China and caused regional impacts. The purpose of the study was to describe the characteristics of the dust storm, the meteorological conditions associated with the dust event and to estimate dust emissions using visibilities measured by new instruments.

The dust storm of 29-31 March 2007 covered most of the territory of Mongolia. Warm and dry weather in the Gobi Desert and the steppe-desert regions from the summer of 2006 to the spring of 2007 might have resulted in high potential evapo-transpiration rates, producing severe soil moisture deficits and reducing vegetation cover. The dust storm was related with the west–east passage of the trough aloft; and the cyclonic activity and frontal systems across the country. Although, high wind speeds associated with cold fronts were the meteorological driving force for the dust event. In the peak day of the dust storm (30 March), wind speed reached 40 m s-1 and visibilities fell to 10 m. The dust event lasted from one hour to 20 hours at various sites per day.

The estimated daily maximum concentrations of $PM_{10}$ were varied from 151 μg $m^{-3}$ to 23847 μg $m^{-3}$ by the Zamyn-Uud equation and 182 μg $m^{-3}$ to 9111 μg $m^{-3}$ by the Dalanzadgad equation during the dust storm period that was in the range of measured levels in the region. The dust storm was the most intense and widespread in Mongolia in 2007 and probably contributing to the wind erosion in the region.

*Result 2: 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 considerable 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 3: Dust storms, forest fire smoke and air pollution detected by polarization-sensitive Mie-Lidar measurements in Mongolia.*

Past decades, lidar has been used to detect intercontinental transport of desert dust, air pollution and forest fire smokes as well as to investigate turbulent processes, planetary boundary layer and meteorological phenomena such as frontal passages, hurricanes and mountain waves and to monitor emission rates and concentration levels of trace gases, the stratospheric ozone deflation etc (Wandinger, 2005). Lidar is contributing to our knowledge of the horizontal and vertical structures of dust storms, forest fire smoke and air pollution.

Polarization-sensitive Mie-scattering lidars for dust storm monitoring were installed at Sainshand and Zamyn-Uud in the Gobi Desert and at the capital city of Ulaanbaatar in 2007. This article reports the first lidar observations of atmospheric aerosols in Mongolia including dust storms, forest fire and air pollution episodes. In the paper, vertical structure and temporal variations of mineral dust and anthropogenic aerosols were studied with the lidar data and results of an aerosol transport model for dust emissions, and the origins and transport of aerosols were analyzed using backward air trajectories.

This is the first study on temporal and spatial distributions of dust storms in Mongolia using lidar measurements. The study results showed that vertical structures of dust storms were diverse. Top heights of dust layers over the Gobi Desert of Mongolia during dust storm periods were varying from 0.5 km to 5.5 km. The averaged top heights of dust layers during dust storm periods were around 2.2 km at Zamyn-Uud and 2.0 km at Sainshand.

The Mie-Lidar observations detected the elevated dust layers transporting from other source regions to the Gobi Desert of Mongolia. Base heights of elevated dust layers were from 0.5 km to 2.5 km, while top heights from 2.5 km to 4.5 km in the troposphere. The study results suggested source areas of the elevated dust. The NW source areas for the transported dust layers over the southeastern Mongolia might be the Gobi Deserts in the Great Lake Depression in the west of the country. The W source area might be the Gobi Deserts in the front side of the Altai Mountain range and the Dzungarian Gobi Desert in NW China. The SW source areas for the transported dust layers might be the Taklamakan Desert and the Badain Jaran Desert in China. The south source areas may possibly be the Gobi Deserts in western Inner Mongolia, the Tenger Desert, Ordos Desert and Maowusu Deserts in the northern region of China.

The lidar parameters at Sainshand and Zamyn-Uud showed the annual variations of dust storms in the Gobi Desert of Mongolia with higher frequencies in March to May. During the study period, dust storm occurrences were higher in April to May 2008 and March 2010 and the spring of 2008 was stormier than springs of 2009-2010.

As well as the lidar observations revealed forest fire smoke and air pollution episodes. The Lidar measurements at Ulaanbaatar, Sainshand and Zamyn-Uud detected forest fire smokes extending from the ground level up to the mid troposphere as well as elevated in the air. The study result disclosed that source areas of the forest fire smokes were the southern Siberia and northern forest area of Mongolia. The Lidar parameters at Sainshand and Zamyn-Uud showed transported air pollution episodes in the southeastern and eastern Mongolia that extended from the ground level up to 3 km AGL. According to the backward air trajectory analyses, polluted air mass come from the central and south eastern regions of China to the southeastern and eastern terrain of Mongolia.

**Dr. Nigussie Haregeweyn AYEHU (Soil Erosion and Conservation)**

April 2010 – March 2011

Mekelle University, Ethiopia

Title: Analysis and modeling of soil erosion processes and conservation efforts in Ethiopia

**Summary of research activities:**

Soil erosion by water is by far the biggest land degradation problem in Ethiopia, if not in the world. Much of the land degradation is found in the highlands located above 1500 m above sea level (~45 % of the total country's total area). The problem is even more severe in the northern Ethiopian highlands, due to a relatively steep topography, erosive rains, and overgrazing and long cultivation history. Accelerated by unwise and improper land use, soil erosion, among other associated impacts, had severely fragmented and damaged productive land, reservoir's life being threatened with rapid sedimentation. On the other hand, the issue of conserving land in Ethiopia as a whole was largely neglected until the early 1970s. But awareness of the problem was initiated by the devastating famine that happened in Wello in 1973/1974. However, data on watershed sediment yield and reservoir sedimentation rates for Ethiopia are not only limited in number and space but they are also unreliable. Moreover, adaptable erosion and sediment yield models, which are important tools for appropriate land management, are currently lacking. There is generally a lack of comprehensive study to what extent land use land cover change driven by urban expansion as well as to what extent the integrated watershed management interventions have effect on the land resources degradation or the vice versa. Therefore, over the last one year, I have been doing research under the theme "analysis and modeling of soil erosion processes and conservation efforts in Ethiopia" based in the Plant Production Division of the Arid Land Research Center (ALRC), Tottori University. The main specific tasks were analysis and write up of about four scientific papers dealing with reservoir sedimentation, watershed management; land use and land cover change driven by urban expansion and modeling of sediment yield, where the details for each are given under Section 3 below.

I have also participated in jointly planned researches, attended and gave seminars, participated in international conference, served as invited reviewer for international journals and also as scientific committee member for international conferences, where each of them are described below.

I have 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 (weekly) seminars, division level meetings, and review of students' papers.

Attended seminars given by other Visiting Researchers, and invited researchers as well as gave own seminars to the staff and students of the ALRC on the following four different topics:

Seminar 1: Fighting desertification in the Tigray Highlands, Ethiopia: lessons to be learnt from successes

and failures of soil erosion control measures: an overview of a Zala Daget project, 21 May 2010

Seminar 2: Reservoir sedimentation in Northern Ethiopia: the case of Angreb domestic water supply dam, 30 June 2010

Seminar 3: Integrated watershed management impacts on soil loss and runoff reduction in Northern Ethiopia, 07 October 2010

Seminar 4: Assessment and evaluation of sediment-bound nutrient export and associated costs from micro-dam catchments in Northern Ethiopia, 26 November 2010.

Two oral presentations at the Environmental Connection 2011(EC11), International Erosion Control Association's 42nd Annual Conference & Trade and Exposition participation in Orlando, Florida, February 20–23, 2011

Presentation 1: Evaluating an integrated watershed management in the Northern Ethiopia (22 February, 2011)

Presentation 2: Reservoir sedimentation and its management options: the case of Angereb dam-catchment, Northwestern Ethiopia (23 February, 2011)

Served as invited reviewer for international journals such as Land Degradation and Development, Journal of Ecohydrology and ICE - Water Management journal.

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:**

* Sedimentation and its mitigating strategies: a case study of Angereb reservoir, northwestern Ethiopia. Journals of Soils and Sediment, under revision.
* Participatory integrated watershed management, an effective approach to curb land degradation: a case study of the Enabered watershed, northern Ethiopia. Journal of Natural Resources Forum, under revision.
* Urban sprawl and smallholder farmers' displacement: a spatio-temporal analysis of land use and land cover change and its associated consequences, a case study on Bahir Dar Town, NW Ethiopia. To be submitted soon to Journal of Urban and Regional Geography.
* Evaluation and adaptation of sediment delivery ratio models leading to accurate sediment yield prediction for catchments in Tigray, Northern Ethiopia. Under preparation.

**Result of the research:**

*Paper 1: 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 aim of this study was therefore to analyze the extent of the sedimentation problem and to propose optimal sediment mitigating strategies.

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, sediment management scenarios based on a sediment balance approach were proposed.

The annual total capacity loss during 1997–2005, 1997–2007, and 2005–2007 was estimated at 4%, 3%, and 3%, respectively, and the variation was attributed to changes in sediment yield. 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 database building, development and standardization of appropriate methodologies for predicting sediment yield, and capacity building of designers.

*Paper 2: Participatory integrated watershed management, an effective approach to curb land degradation: a case study of the Enabered watershed, northern Ethiopia.*

This study assessed the impacts of IWM on (1) land use and land cover change and (2) reduction of soil loss due to sheet and rill and gully erosion and runoff in the Enabered watershed. Changes in land use/land cover and soil and runoff losses were compared before and after the IWM interventions, and watershed characteristics and implemented IWM measures were mapped in the field. Plantations and exclosures showed a significant increase at the expense of grazing and bushlands. Sheet and rill erosion and runoff decreased by 89% and 27%, respectively, while gully channels refilled by 96%. The decrease in sheet and rill erosion resulted from changes in surface cover (48%) and conservation practice (29%) factors, as represented by *C* and *P* of the universal soil loss equation. The results revealed that participatory IWM is an effective approach to combat land degradation. Full participation of the local community at all levels of the project was the key factor for this success. Because decisions about ways to combat land degradation and enhance productivity of degraded lands were made using a rational process-based approach, IWM may be implemented in other countries with similar land and socioeconomic situations.

*Paper 3: Urban sprawl and smallholder farmers' displacement: a spatio-temporal analysis of land use and land cover change and its associated consequences, a case study on Bahir Dar Town, NW Ethiopia.*

This study evaluated the extent of town sprawl and its impact on the surrounding rural small holder farmers and then proposed options useful for a sustainable planning and implementation of urban expansion, taking a case study of Bahir Dar town, NW Ethiopia. Aerial photographs of the years 1957, 1984 and 1994 were used to generate the boundary and land cover map for the study area using a Geographic Information System. While the 2009 boundary of the town was delineated from GPS readings taken during the same period. About 271 affected households by the town's expansion complimented with focused-group discussions were used to assess and evaluate the impacts of urban expansion on the

surrounding rural communities. Results showed that, the Bahir Dar town had expanded significantly from 279 ha in 1957 to 4829 ha in 2009, by about 32% every year. As a result land use/ land cover change had occurred due to both the horizontal expansions as well as the intensification of the town. The intensification analysis for the period 1957-1994 showed that built up area showed increment by about 195%. On the other hand, the per capita land consumption has decreased from 0.1 to 0.02 during the same period.

The main factors that contributed for this urban expansion were: rapid population growth (on average by 5% per annum) which in turn has increased the demand for more housing then for more land, increased demand for construction of office buildings and associated facilities especially after the town has been promoted to be a seat of the regional capital of about 17 million people, lack of well defined policy and master plan depicting the long-term development of the town which opened a room for irregular settlers and developers.

The expansion of the town has brought both positive and negative consequences to the surrounding rural communities of the town though the latter outweighs the earlier. Between 2004 and 2009 alone, a total of 242.2 hectares of farmland from 271 sample households have been encroached due to the expansion. The total livestock number per household head had reduced by 24%. Though 97% of affected farmer households have been compensated money for expropriation of farmland, about 96% of them believe that the amount of money was by far less compared to the benefits they were obtaining from the land before expropriations as the affected farmers did not participate directly in the decision process as well as due to government's ownership of the land. Moreover, the money compensation was provided without appropriate training and advisory services on how to utilize and invest the compensation money in some profit making activities. As a result about 13% of those who received the compensation money spent the entire compensation for their home consumption.

As a result, majority of the affected farmer households have negative attitude towards the expansion of the town. Prediction of agricultural land loss due to urban expansion showed that, if the current expansion trend continues, the current size of the town will double just after 15 years in 2024. This will aggravate further the dislocation of farmer households and may lead to food insecurity and social unrest among affected farmers as well as to the surrounding rural communities of the town. Though it is a general understanding that urbanization is one of development features, the form of expansion should not be in such a sprawl manner that consumes large amounts of farmlands and risk the livelihood of the surrounding farmers. Therefore, a long-term master plan detailing the rate and type of expansion as well as a clear policy on the compensations modalities involving affected farmers are crucial if the expansion is to remain as sustainable.

*Paper 4: Evaluation and adaptation of sediment delivery ratio models leading to accurate sediment yield prediction for catchments in Tigray, Northern Ethiopia.*

Sediment yield can be quantified using the sediment delivery ratio (SDR), expressed as the percent of gross soil erosion by water that is delivered to a particular point in the drainage system. There are different methods to estimate SDR (Lu et al., 2009; Ouyang and Bartholic, 2009).

Therefore in this paper sediment delivery ratio for 11-micro-dam catchments (1-24 $km^2$) in Tigray, northern Ethiopia, were determined by dividing the sediment yield obtained through reservoir sediment survey to the total predicted erosion by sheet and rill and gully. The sheet and rill erosion were estimated using the revised Universal Soil loss (RUSLE) equation adapted for Ethiopian conditions (Hurni, 1985; Nyssen et al., 2004; and Haregeweyn et al. 2011). While, gully erosion will be accounted for based on

estimates of gully erosion rates for the area as determined by Nyssen et al. (2006) and Haregeweyn et al. (in prep.). Then once SDR for the 12 catchments is determined, empirical relationships relating SDR to catchment properties were established which can potentially be useful to understand the sediment delivery characteristics of Ethiopian river basins.

Testing of existing models showed that no model is found adoptable to the study area as it is. So calibrations remain important. A newly established relationship between catchment characteristics and sediment delivery ratio yielded that drainage length and drainage area as the most significantly influencing SDR. However validation of the model remains to be done on a separate datasets, which is the main bottle neck of this study until now.

**Dr. Zahoor AHMAD (Soil and Water Quality)**

October 2010 – September 2011

The Japan Society for the Promotion of Science

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

**Research background**:

Application of phosphorus (P) fertilizers on agricultural lands is increasing day by day, especially in developing countries, and world P fertilizer demand is predicted to increase by approximately 2.7% per year during the next decade. Continuous application of either organic (bone meal, cottonseed meal, fish emulsions, manures and processed sewage sludge) or inorganic (reactive rock phosphates, acidulated phosphates and thermophosphates) sources of P fertilizers saturated the soils to such an extent that the loss of P in surface runoff is now a priority management concern in many parts of the world. Agriculture is the primary source of non-point source pollution degrading the quality of streams and lakes. To reduce this P transport to surface water bodies, many strategies and management practices have been investigated. Some management practices include the shift of manure application to P bases, stopping land application of fertilizers once the threshold soil test P value is reached, and use of environmental soil tests to assess P sorption capacity instead of agronomic soil P testing methods. But P based compost application or stopping P application will not serve the goals because there are still many highly P contaminated soils which are posing threats to the environment. It has been estimates that without further P addition, 16 to 18 years of cropping corn or soybean would be needed to deplete the soil test P contents (Mehlich III) of soil from 100 mg P $kg^{-1}$ to the threshold agronomic level of 20 mg P $kg^{-1}$.

Additional best management practices have also been investigated, including conservation tillage, crop residue management, cover crops, buffer strips, contour tillage, runoff water impoundment, and terracing to reduce the P mobility. But these strategies are comparatively more effective in controlling particulate P than the dissolved (or labile) P in agricultural runoff water. Therefore, to reduce the dissolved P in runoff water or to increase the soil P holding capacity, a number of soil amendments have been attempted. As P has high affinity towards the oxides of iron, aluminium and calcium carbonates present in soil, any material which has high contents of these elements will ultimately increase the soil P holding capacity. Blast furnace slag (BFS) is also one of the materials which consist primarily of silicates, alumino-silicates, and calcium-alumina-silicates. Blast furnace slag is a nonmetallic co-product which is produced in iron industry and has been used as a P adsorbent in wastewater-treatment systems. However, the use of BFS on agricultural lands to reduce the P mobility has not been investigated yet. Similarly, drinking water

treatment residuals (WTR) are the waste obtained after the purification of drinking water. Aluminum, Fe or Ca salts are used as coagulants during drinking water treatment therefore the residues also contain high amount of these chemicals which make this material ideal to be applied on soils as a P sorbent material. Analogously, Hydrotalcites (HYD) is relatively a new material used for P adsorption. It belongs to a group known as layered double hydroxides (LDH). Hydrotalcites are anionic clays, which have been relatively unknown although these minerals are quite prevalent in nature. Hydrotalcites can also be synthesized from a broad range of compositions. Use of hydrotalcite like compounds ($M_{1-x}^{2+}M_x^{3+}(OH)_2(A_{n-})_{x/n}.yH_2O$) has been increased tremendously in wastewater treatment systems over the last few years. Use of HYD as a P adsorbent in soil has not been investigated yet. Therefore, overall objectives of the study were to i) test the use of BFS, WTR and HYD as P adsorbent in the soil, ii) evaluate the P leaching from soils amended with these materials, and iii) study the response of maize (*Zea mays* L.) crop in terms of growth and nutrient uptake.

**Methodology:**

To achieve the goals, a greenhouse pot experiment was conducted to evaluate the effect of BFS, WTR and HYD on the maize (*Zea mays* L.) 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. 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.

**Results:**

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 equal in HYD amended pots as compared to the control treatment.

Analysis of leachate collected over the time shows that DRP concentration significantly varies with soil type. Overall DRP concentrations 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.

Experiment is under way to get the data on nutrient uptake by maize plant and draw the final conclusion.

**Publications:**

(i) Zahoor Ahmad, Mohamed A. M. Abd-elbasit, Mitsuhiro Inoue, Hiroshi Yasuda, Toshimasa Honna, and Sadahiro Yamamoto. 2011. Use of two industrial wastes as soil amendments: effect on dissolved reactive phosphorus in runoff. Soil and Sediment Contamination (Accepted).

(ii) Uzoma, K.C., M. Inoue, H. Andry, A. Zahoor and E. Nishihara 2011. Influence of biochar application on sandy soil hydraulic properties and nutrient retention. Journal of Food, Agriculture and Environment (Accepted).

(iii) 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 (Accepted).

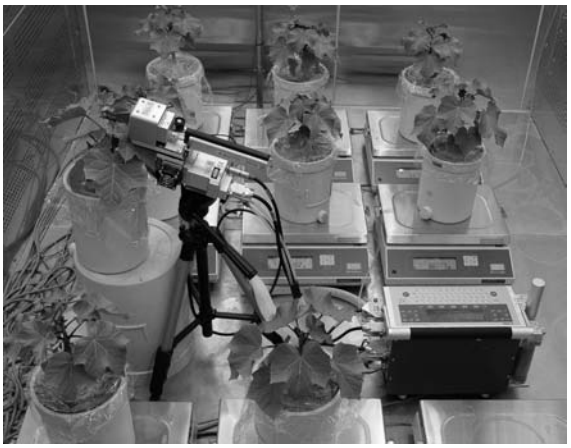
**Open Seminar**

Use of different soil amendments to protect the environment from phosphorus pollution. Arid Land Research Center, February 8, 2011.

### (4) Project Researchers

**Dr. Hisashi Tomemori (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
- 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 discussion about collaborative research and experiments.

**Dr. Tomoe Inoue (Crop Physiology)**

Research has been conducted to characterize the morph-physiological mechanisms mediating drought and heat resistance in wheat in collaboration with scientists at the International Center for Agricultural Research in the Dry Areas (ICARDA, Syria). In the fiscal 2010, I studied on dry matter production and its distribution of winter/facultative wheat under terminal drought and heat stress conditions.

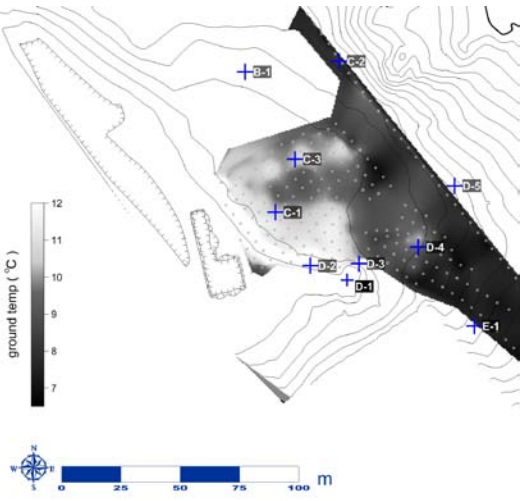
I also studied on root hemi-parasitic weed *Striga*, one of the most serious constrains on crop production in the dry areas of Africa. *Striga* damage to crops is more serious under drought than under favorable condition. To clarify the mechanisms regulating water and solutes uptake of *S. hermonthica* from host

plants, I have conducted joint research at the Sudan University of Science and Technology. In the fiscal 2010, photosynthetic capacity and stomatal response of *S. hermonthica* and host sorghum were evaluated under different water regimes.

Overseas activities during the fiscal 2010 were included; visit to ICARDA to conduct joint research on drought and heat resistance in wheat; visit to the Sudan University of Science and Technology to conduct joint research on *S. hermonthica*; and participation in the international conference held in Cairo, Egypt.

**Dr. Takayuki Kawai (Groundwater hydrology)**

To develop new groundwater inquiry technology in sandy area, various hydrological phenomena were researched. The content of the research was to analyze the influence of sediment heterogeneity on groundwater flow with the various type of physical properties. The figure showed the result of high-groundwater flow points with 1 m deep ground temperature under same groundwater depth in sandy soil.




Heterogeneity of groundwater flow and ground temperature

The main grant was the Japan Society of the Promotion of Science Grants-in-Aid for Scientific Research (B), 2010-2012 and Japan Society of the Promotion of Science Grants-in-Aid for Scientific Research (C), 2008-2010 (Project Leader: Kamichika M.).

**Dr. Yasunori Kurosaki (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. He also made some version upgrades. One of them is the display of present weather for meteorological stations where automatic observations for present weather are conducted. 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), he made analyses of dust emission frequency, strong wind frequency, and threshold wind speed in East Asia. From these analyses, he sought to determine whether the increase of dust emissions was caused by changing erosivity or erodibility. He found that 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). 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. He also made analyses of precipitation amount and NDVI. The analyses suggested that changes in the ground cover provided by dead leaves in the spring could be the driving factor in grasslands Mongolia. A paper, which describes these results, was submitted to Geophysical

Research Letter.

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)

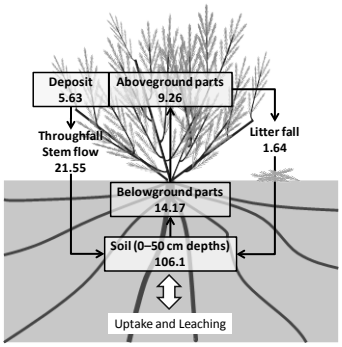
**Dr. Shigeoki Moritani (Soil Management)**

Soil degradation resulting from wind-induced erosion is a serious problem in drylands, and will remain so throughout this century. The detachment and transport of soil particles degrade the fertility of agricultural land and consequently reduce its productivity. The addition of organic matter increases the connection between aggregate by physical and chemical bounding. The bigger aggregate decreases the wind erosion due to their heaviness. In this research the wind tunnel experiment was conducted inside an existence climate chamber. This chamber is used to control wind velocity at maximum of 3 m/s which is not enough for producing wind erosion. As a result, the wind tunnel was redesigning in order to produce a wind velocity of 12 m/s by narrowing the cross-section of wind path by wood boards.

The treatment of 1, 5 and 10% mixture with organic matter decreased the eroded soil by 14.2, 68.3 and 92.2%, respectively. This result shows that incorporation of the organic material with fiber shape can be used as wind erosion conservation that leads to the sustainable agriculture in the sandy soil.

**Dr. Shogo Imada (Root Ecology)**

The research of the Root Ecology Subdivision is conducted to reveal fine-root and whole-plant responses of trees in response to water table depth, soil drought and salinity conditions. Tamarisk (*Tamarix* spp.), native to Eurasia and northern Africa, has invaded in almost all river systems in arid regions of the western United States. Investigating the cophysiology of invasive tamarisks is important to understand the invasion mechanisms of the species in the regions.




Summary of the Na dynamics of the *T. ramosissima* stand in the Virgin River, Nevada from September 2009 to September 2010. Rectangles represent salt pools (g $m^{-2}$) and arrows show salt fluxes (g $m^{-2}$ $year^{-1}$).

The main studies in this fiscal year were to investigate the salt dynamics, salt secretion patterns from salt glands and fine-root dynamics of tamarisk cuttings under different salinity conditions. Overseas research activities included a short term visit to the Desert Research Institute (DRI), Nevada, USA in order to collect samples and have a meeting for the global COE program and a long-term visit in the DRI to receive training and draft manuscripts.

**Dr. Fumiko Iwanaga (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 present 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, including *Tamarix ramossissima* as an important reforestation species in the

western part of China.

**Dr. Li Li (Rural planning)**

Effects of the Grain for Green Program on Rural Development

**Dr. Yunxiang Cheng (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
- Plant communities of Great Gobi A Strictly Protected Area, Mongolia

The main fellowship grants were the discretion from the Tottori University's president and the Japan Science Society.

**Dr. Andry Henintsoa Ravolonantenaina (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.

Tomato growth on sandy soil under hydrophilic polymers and saline water irrigation conditions

Water and Land Management Subdivision conducts research on the maintaining of a proper supply of organic matter in the soil, maintaining of a proper nutrient and water supplies, and 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.

**Dr. Nandintsetseg Banzragch (JSPS Postdoctoral Fellow)**

(October 2010 – March 2011)

Title: Developing an ecosystem model for an integrated wind-erosion scheme

Research was conducted to develop an ecosystem model for an integrated wind-erosion scheme by analyzing the mechanisms of vegetation/soil moisture and aeolian processes in the arid regions of East Asia, particularly in the Mongolian steppe, which are the main source of severe dust events. Research activities during the period of October, 2010 – March, 2011 are:

1) *Data collection and analysis.*
   - The land surface and meteorological data were collected from the selected 15 stations (distributed widely across the Mongolian steppe) for the period of 1986–2010 by the Institute of Meteorology and Hydrology (IMH) of Mongolia. These data will be used for analyzing the mechanisms of vegetation/soil moisture and aeolian processes, and developing an ecosystem model. Additionally, remotely sensed observations collected from AVHHR and MODIS are also used for model validations.
   - Statistical analyses of the mechanism of vegetation/soil moisture and aeolian processes, and their memory effect on dust emission using the collected long-term data.
2) *Field experiment preparation and observations.*
   - In order to obtain the model input parameters and its validation, we set up four different research sites based on plant species at the Bayan-Unjuul, which is a research site of the DUVEX (Dust-Vegetation Interaction Experiment) project at the Arid Land Research Center, Tottori University project. The land surface parameters such as plant biomass and soil moisture were measured at the research site.
   - *Equipment preparation:* The automat weather station (AWS) and soil moisture sensors were purchased. This equipment has been tested before sending to the research site in Mongolia. All soil moisture sensors have been tested on sandy soil with different soil moisture contents at the ALRC, Tottori University.
3) *Model selection and development.* We have selected suitable ecosystem models such as DayCent4.5, Biome-BGC4.1.2 and Sim-Cycle for the Mongolian grasslands based on the model performance (calibration and validation) and parameterizations. We are in the process of modification of the selected models so as to be able to simulate the realistic land-surface conditions (such as soil moisture and vegetation memory) controlling the dust emission in the study area.

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

*Spatiotemporal assessment of rainfall erosivity in Loess Plateau, China*

**Background:**

Soil erosion by water is one of the major causes of land degradation. The Chinese Loess Plateau has a high level of soil water erosion. The major reason for the severity of soil erosion in Loess Plateau can be attributed to three non-anthropogenic factors: rainfall erosivity, slope gradient, and loess soil type. The rainfall erosivity is controlled by the rainfall characteristics. Generally, rainfall characteristics change drastically in space and time. In this study, the spatial and temporal variability of rainfall erosivity in Loess Plateau, China has been investigated.

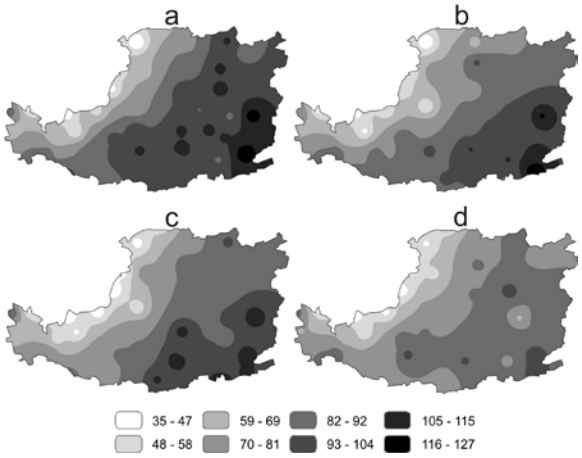
**Methodology:**

Rainfall data collected from 42 stations in Loess Plateau for the period from 1960-2000 were used. The rainfall erosivity has been investigated using the modified Fournier Index (MFI), annual rainfall, and Precipitation Concentration Index (PCI).

**Results:**

The study showed a decrease in average MFI by 10%. However, the difference between the MFI in 1960s and 1990s is found to decrease in a larger proportion of the area in Loess Plateau, whereas there is increase in limited locations at the high latitude. The maximum decrease in the rainfall erosivity was higher in the southeast than that in the north and west. The $P_y$ was found to have a trend similar to the MFI, which further indicates that the MFI follows to a high extent, the annual rainfall trend. The PCI was found to have trend opposite to MFI and $P_y$. The PCI increased in the north and west and decreased toward the southeast. The average temporal difference in the PCI between 1960s and 1990 was 2%. The decrease in rainfall erosivity in Loess Plateau, China should have a subsequent decrease in sediment yield, assuming that the other factors remain constant. However, there was a decrease in the annual rainfall which affects development of good vegetation cover, and thus enhancing the potential for more sediment generation.

Spatiotemporal modified Fournier Index distribution in the Chinese Loess Plateau. (a) modified Fournier Index rainfall 1960s, (b) modified Fournier Index rainfall 1970s, (c) modified Fournier Index 1980s, and (d) modified Fournier Index 1990s.




*Mesquite (Prosopis Spp.) Water Uptake under Different Simulated Drought Conditions*

**Background:**

Mesquite ( Prosopis spp.), an ever green plant plays an ecological, economical, and hydrological roles in desert environments. The mesquite has been classified as a phreatophytes plant; i.e. has access to constantly saturated water reservoirs. The mesquite has been introduced to several parts of the arid areas in order to rehabilitate the degraded lands and stop the continuous desert creeping. In Sudan, the mesquite has been planted in Khartoum since 1917 and then the area was expanded to cover different parts of Sudan for similar purposes (Babiker, 2006). Currently, mesquite has been classifies as a major non-indigenous (alien species) weed in Sudan. The mesquite pant has been proved to have two mechanisms to survive under hard arid conditions: first the phreatophytism and drought resistance. These two mechanisms support the mesquite during the prolonged drought conditions, which makes mesquite, compete successfully with the natural indigenous species. In this study, the drought resistance mechanism will be investigated due to its importance in mesquite expansion in arid environment. The main objectives of this study are to study the

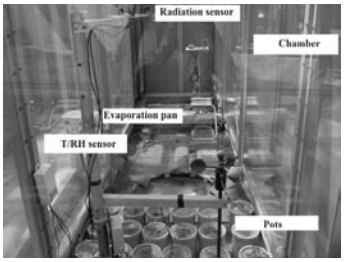
response of mesquite plant to different drought levels and to identify some plant parameters that can be compared with the indigenous species in Sudan and arid environment.

**Methodology:**

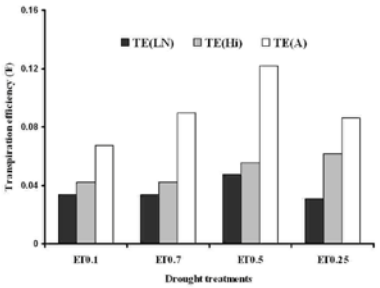
Pot experiment was carried out at the Arid Land Research Center, Tottori University under controlled growth chamber system. The growth chamber used in this study has area equal to 6 $m^2$ and the top and side walls were transparent to allow natural sun-light to penetrate. The chamber is equipped by computer system in order to control the temperature, humidity, and wind speed with error less than 5 percent. Air temperature, relative humidity, and wind speed of the chamber were fixed on 33ºC, 0.4, and 0.9 m $s^{-1}$, respectively. The air temperature (T) and relative humidity (RH) was also monitored in 10 minute interval. The pot diameter was 25 cm and 30 cm height. The pots were filled with dune sand. Four drought treatments have been used: 100, 70, 50, 25 % ($ET_{1.0}$, $ET_{0.7}$, $ET_{0.5}$, and $ET_{0.25}$, respectively) of the potential evapotraspiration evaluated by the pan evaporation. The plant transpiration was evaluated using from pot and leaf scale.

**Results:**

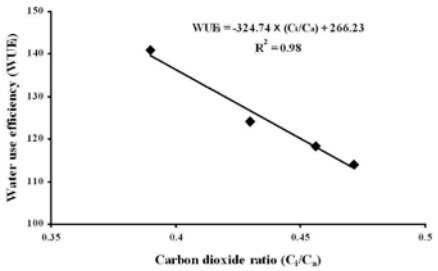
The response of mesquite to different drought levels was investigated. The mesquite showed high adaptability to drought level during a short period of experimental time. Although the water supply was decreased by 75%, the mesquite was efficiently survived with high transpiration and water use efficiencies. The intrinsic water use efficiency showed high value compare with Acacia sp. which gives good explanation for the expansion of mesquite in Sudan. Also, significant relationship between the intrinsic water efficiency and intercellular and atmospheric $CO_2$ ratio was achieved. In this study, several plant parameters have been identified in order to compare the performance of mesquite under drought condition with indigenous species. However, the $WUE_i$ can be considered as efficient index to be used for this purpose.




Growth chamber




Transpiration efficiency




Intrinsic water use efficiency