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А д р е с р е д а к ц и и: 679016, г. Биробиджан, ул. Шолом-Алейхема, 4
ИКАРП ДВО РАН, тел./факс: 4-16-71, http://икарп.рф
E-mail: **reg.probl@yandex.ru**

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FOREWORD

FOR THE 'REGIONAL PROBLEMS' SPECIAL ISSUE ON **"CLIMATE CHANGE ADAPTATION AND MITIGATION: SUSTAINABLE AGRICULTURE AND HEALTH SECURITY"**

International Workshop "Climate change adaptation and mitigation: sustainable agriculture and health security" was jointly organised by the Association of Academies and Societies of Sciences in Asia (AASSA), the Far Eastern Branch of the Russian Academy of Sciences (FEB RAS) and Institute for Complex Analysis of Regional Problems of the Far Eastern Branch of the Russian Academy of Sciences (ICARP FEB RAS), and supported by the InterAcademy Partnership (IAP). International Workshop was held in Birobidzhan from 1st to 5th October, 2018, with an ultimate goal to strengthen research and innovation activities in the field of climate change impact on human health, agriculture production and social security.

The United Nations' 2030 Agenda for Sustainable Development targets global science community on achieving Sustainable Development Goals (SDGs) for the future well-being of the planet. In accordance with SDGs, the IAP Strategic Plan (2016 – 2018) addresses health, water and food security as critical development challenges, which require scientific and technological progress.

There is growing scientific consensus that climate change is happening, and will have serious consequences for human health. One aspect of the ongoing discussion and exploration of climate change is the increased mortality threat of climate change on the planet's human population. As world population continues to grow along with change in global climate, a greater portion of humanity is threatened by a multitude of climate and weather phenomena. The near-term and medium-term is a time to promote adaptation measures that will reduce the damage to health caused by climate change, to which the world is already committed. The main goal is arising awareness of authorities, large and private households and the public about climate change issues, opportunities and ways of adaptation.

Climate change continually affects our capabilities to feed the increasing population. Agricultural production is extremely vulnerable to climate change impacts with serious potential consequences to society. Understanding how and to what extent climate change may affect agricultural productivity is of great significance for adapting to future climate change.The possible increases in extreme weather events caused by global warming, may pose an increasing risk to global crop production. Crop productivity may also be affected by other factors, such as the occurrence of pests and diseases, which are closely associated with climate change. Thus, the relative potential of adaptation strategies should be developed and evaluated for coping with climate risk.

To end poverty and hunger and make human life inclusive, safe, resilient and sustainable, it is essential to strengthen capacity for adaptation to climate change and mitigation management at all levels. Considering the present realities involving serious impact of extreme weather on environment, particularly on human health and agriculture, forecasts of future climate are required for effective decision-making, to provide social security and sustainable agriculture development, mitigating impacts or taking advantage of changed opportunities.

The AASSA – FEB RAS International Workshop is aimed to (1) cut across the different disciplines of science to present the best practices into key societal challenges including food and nutrition security, health and wellbeing, sustainable growth, (2) involve scientists and experts to collaborate with for the development of reliable as well as economically and environmentally sustainable approaches for adaptation to and mitigation of climate change.

The main topics under discussion are as follows:

- Climate Change and Human Health
- Climate Change and Sustainable Agriculture
- Climate Change: Challenges for Agricultural Environment
- Climate change: Challenges for Food and Social Security

Each Session began with an initial lecture presented by international well known experts. They gave to the participants an important update on the "state of the art" in the different fields of climate human health and agriculture.

A selection of full papers and abstracts from International Workshop is included in Special Issue of "Regional Problems". This is the first printed in scientific journal reference of AASSA regional activities. With that, the publication of this Special Issue highlights the visibility of AASSA in regional and national scientific and social development. Moreover, the publication is coincident with UN foregrounds, focusing research resources on priority issues of sustainable development goals, facing real and potential impacts of climate and weather variability on human society.

Dr. Elena A. Grigorieva,
on behalf of
International Workshop National Organizing Committee
and
Editorial Board of Scientific Journal "Regional Problems".

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CLIMATE CHANGE AND HUMAN HEALTH

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INCREASING TEMPERATURE EXTREMES AND THERMAL DISCOMFORT OVER SOUTHERN INDIA: CONCERNS FOR HUMAN HEALTH

Amit G. Dhorde*, Manasi Desai
Savitribai Phule Pune University, Maharashtra, India
Email: amitdhorde@unipune.ac.in (*corresponding author)

The paper analyses trends in temperature extremes such as hot days, very hot days and extremely hot days over southern India during summer season for the period 1969 to 2015. Tendencies in human thermal discomfort have also been worked out for the same time period. Linear regression and Mann-Kendall test were applied for time series analysis. Human thermal discomfort was investigated using Heat Index (HI) and Wet Bulb Globe temperature (WBGT) indices. It was observed that hot days and very hot days have increased during the study period over southern half of the study area. The rate of change is higher and significant over west coast. Consequently an increase in discomfort was observed over west coast during all summer months, which are March, April and May. During April and May even the east coast stations revealed significant upward trend in discomfort. Even some inland stations have registered rising tendencies in discomfort. It reveals that the heat stress is rising in the southern India, which is a major health concern for the population living in this area. There is a need to develop a warning system of heat stress, which will help in preventing casualties due to heat stress.

***Keywords**: Temperature Extremes, Heat Index, Thermal Discomfort, Trend Analysis, South India.*

Introduction

Due to its tropical location India is subjected to high temperatures during Northern Hemispheric summer. The temperatures are still higher over Southern India due to its proximity to the equator. In general the population of this region has been traditionally exposed to higher temperatures, but at times these temperatures cross the threshold in the form of heat waves and high temperature extremes which results in numerous heat related casualties in this area. If the heat wave episodes and frequency of high temperature extremes keeps on increasing, it will have a profound impact on the social as well as natural systems. This is the general belief that reflects in the literature on climate change and its impacts on human society and ecosystem. In fact the Intergovernmental Panel on Climate Change (IPCC) estimates increased probability of longer heat waves, higher frequency of their occurrence, and also greater intensity over most of the land areas [2]. Therefore, according to researchers the study of climate change should not be restricted to mean climate, it should include extremes.

India is one of the fastest growing economies of the world and is also the second largest populated country of the world. It is strongly dependent on human resource which is concentrated in urban areas, dwelling on insufficient urban resource. Having a large human resource is advantageous, but the demographic characteristics and socio-economic factors threaten and impede adaptive capacity of population to deal with heat stress adversities [5]. Thus the higher temperatures and socio-economic factors make the Indian population highly vulnerable to thermal stress. Thermal stress is very closely associated with human health. The two heat waves that occurred in Europe in June and August 2003 were responsible for many thousands of deaths [7]. Hence it becomes essential to assess regional tendencies in temperature extremes on one hand and also to investigate trends in thermal discomfort on the other. Thus, this paper focuses on spatio-temporal variations in temperature extremes over southern India. Secondly, it also highlights trends in thermal discomfort using indices such as Heat Index (HI) and Wet Bulb Globe Temperature (WBGT). The study has been particularly carried out for pre-monsoon (March, April, May) and Monsoon (June, July, August, September) seasons.

Study Area, Data and Methods

The study area under consideration is southern India which includes the mainland south of Tropic

of Cancer. For thermal discomfort analysis 41 urban weather stations were selected based on the availability of data and its homogeneity. For the analysis of temperature extremes 62 weather stations of southern India were considered. The area has tropical wet and dry climate. It is a typical monsoonal climate. Wet period is confined to southwest monsoon season (June to September) over most of the peninsular region, whereas eastern coastal region experiences wet season during northeast monsoon season (October to December). The central part of Indian peninsular region receives meagre rainfall and thus is subjected to hot and dry climate. Summer season is marked by scorching heat and commencement of monsoon leads to muggy, sultry weather conditions. Thus, during monsoon season transition from hot summer to humid monsoon with intermittent breaks apparently builds heat stress pertaining to tropical hot temperature and high atmospheric humidity.

The data required for the study were obtained from National Data Center (NDC) of India Meteorological Department (IMD). For the assessment of temperature extremes daily data of maximum temperature (TMAX) was collected. For discomfort indices along with TMAX data for daily minimum temperature (TMIN), dry bulb temperature (DBT), wet bulb temperature (WBT), dew point temperature (DPT), relative humidity (RH), wind speed (WS) and vapour pressure (VP) was obtained for the period 1969–2015.

Hot extremes were defined based on the percentiles. A hot day was defined as a day when maximum temperature value remained between 90th and 95th percentile. A very hot day was defined when the TMAX value remained between 95th and 99th percentile and extremely hot day was defined when TMAX remained above 99th percentile. The analysis of human thermal comfort/discomfort was carried out using Heat Index (HI) and Wet Bulb Globe temperature (WBGT) indices. HI is a direct index which is based on direct measurements of environmental variables. It is also known as apparent temperature and was proposed by Steadman [6]. WBGT is one of the empirical indices based on objective strain response data obtained on individuals and group of individuals exposed to various levels and combinations of environmental and metabolic heat stress factors [3]. A time series was constructed for HI, WBGT, and temperature extremes which was then analysed using linear regression. Statistical significance of the obtained trends was tested with students t-test for 95% of confidence level (0.05 significance level). The significance was double checked with Mann-Kendall rank test.

Results and Discussion

"Extremes in temperature are characterized by daily temperature level exceeding tolerable limits, and their frequency and spell duration are of great interest in terms of human impacts" [4]. The limits here have been defined using percentiles. The lower limit of the percentiles taken was 90th percentile going up to 99th percentile. The rate of change obtained through linear regression was converted to decadal trend. Majority of the stations indicated rising tendencies in hot days, very hot days and extremely hot days (Figure 1). Higher number of significant trends were observed in hot days and very hot days. For hot days it was observed that the cities located in south have registered higher rates indicating that hot days and very hot days are increasing swiftly over this region. Another significant finding indicated faster rate among the west coast cities. This also includes the city of Mumbai, commercial and economic capital of India. Faster rates were also observed in the interior. Extremely hot days are on the rise but with few significant trends. Revadekar et al. [4] considered 121 stations for whole of India. They also observed the tendency of Indian region towards a warmer climate and increased frequency of warm events during 1971–2003. Further they found association of these events with El Niño and La Niña events. Another study carried out at the Department of Geography, Savitribai Phule Pune University found rising sea surface temperatures near the west coast of southern India.

To get a detailed picture thermal discomfort analysis was carried out at monthly scale. Initially heat index was computed for 41 urban centers of southern India. The rate of change in case of heat index was converted to absolute change seen over the study period, which is 46 years. The maps obtained are illustrated in Figure 2. During March it was observed that the cities over the southern tip indicate very high rate of increase in HI which is statistically significant. At some of the west coast stations the rate is more than 4°C which is alarming. The northeastern region of the study area registered increase in HI but the trends were not significant. The southern stations of the east coast experienced significant increase than northern stations.

During April the increase in HI is more or less uniform over southern India. Over central area the rise is about 2–4°C over some locations. Similar rates are observed over northeastern locations, but the rise is now significant over here which was not the case in March. The magnitude of increase is again higher over west coast with one exception that is of the city Ratnagiri. The level of urbanization in this city is

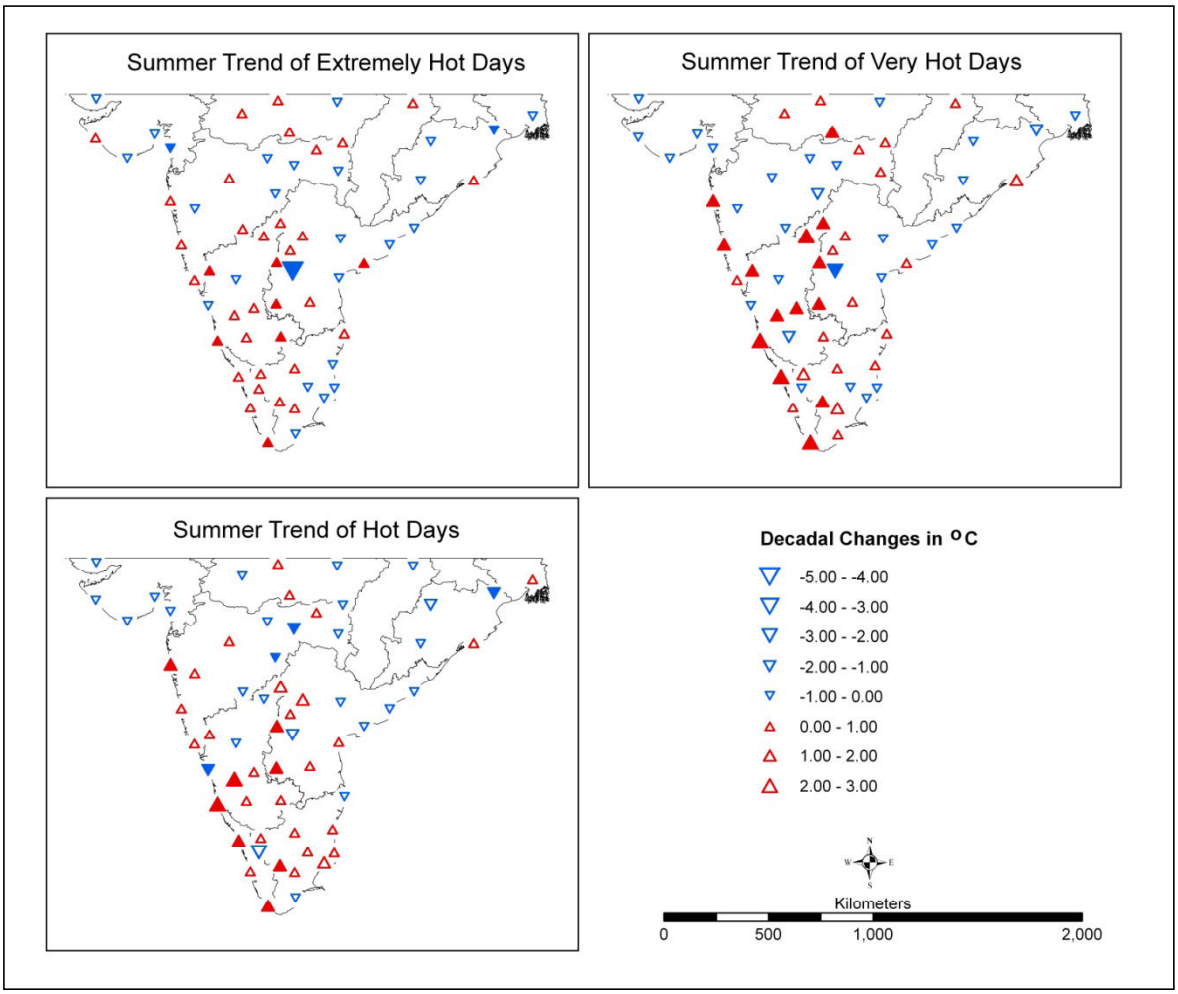

Figure 1. Decadal trends in hot days, very hot days and extremely hot days during summer (Note: hollow triangles indicate insignificant trends and filled triangles indicate significant trends. Upward pointing triangles show positive trends)

low, the population increase is not rapid, there is no in migration in the city which has lead to slow development of the city. During the month of May only four stations indicated decrease in HI, whereas all others indicated rise in HI with majority of them registering significant rising trends. The highest magnitude of increase is observed is again observed at the coastal locations. One of the common features in the west and east coast stations is that the stations on both the coasts show upward trend and more than 70% are significant trends. During May temperatures are very high over most of the southern India. At times the central and eastern parts of the study area are subjected to heat waves. Similar results were obtained for WBGT. The hot days and very hot days are increasing over west coast (Figure 1). Moisture from the adjoining seas is also brought inland by the local winds. Increasing HI is the result of increasing temperatures whereas individual analysis of some stations indicated increase in RH also.

Conclusion

There is no doubt that the temperature extremes over southern India are increasing. On the other hand, the cities of south India are urbanizing very fast. It includes cities such as Mumbai, Pune, Bengaluru, Chennai, Kolkata, Hyderabad which are among the top drivers of Indian economy. The unskilled and moderately skilled population which earns wages by working in the outdoor environment is exposed to high heat stress / thermal discomfort which are also increasing in majority of the cities. Besides this people have to travel long distances in the cities from their home to the work place which increases their risk of exposure to high heat stress. The eastern and western coasts are attractive tourist destinations for the people living inland. Therefore, these coasts are visited by millions of tourists even during summers. The rates observed in the rising HI are alarming and indicate detrimental consequences for the population that is exposed to such a high heat stress. It is there-

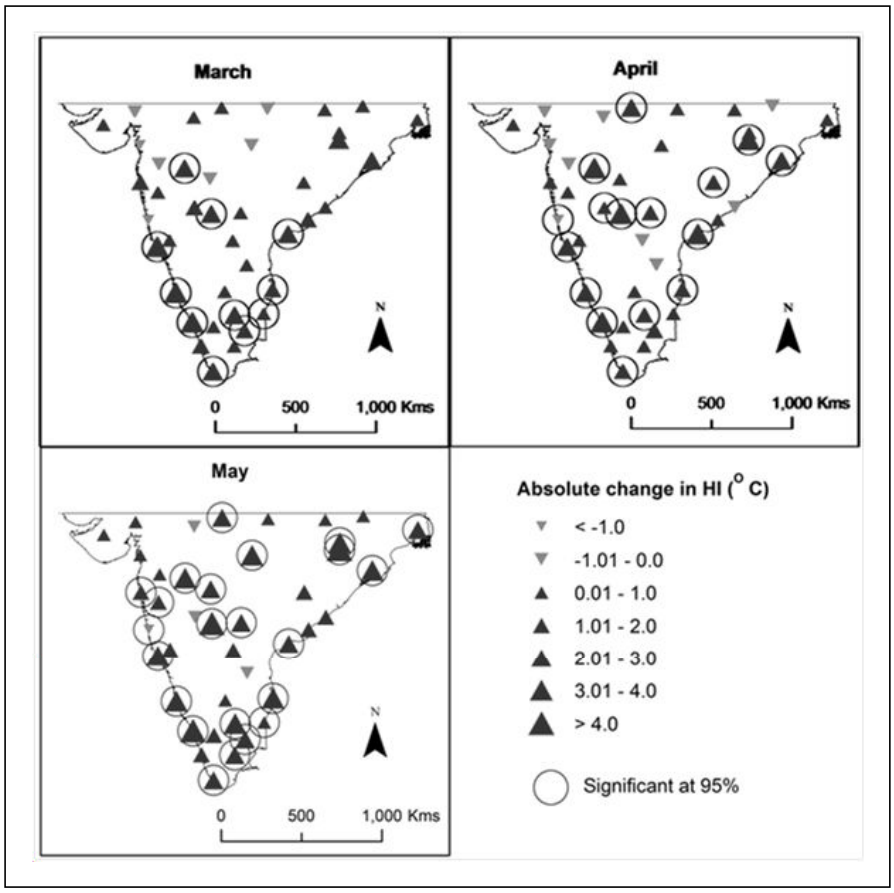

Figure 2. Absolute change in Heat Index (HI) during summer months

fore necessary to develop a warning system for the people which would help them to take adaptive and preventive measures during the high thermal discomfort days. Every year hundreds of lives are lost due to thermal stress during summer months. Thus, the increasing thermal discomfort over southern India is a major concern with respect to the health of the citizens. Another consequence will be on the cooling energy demand. Due to increasing thermal discomfort the energy demand will increase and this will put extra pressure on south Indian states which are already facing power shortage.

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UDK 551.586(510)

SPATIAL-TEMPORAL PATTERNS OF TRAVEL CLIMATE COMFORTABLE PERIOD IN NORTHEAST CHINA FROM 1981 TO 2010

Yezhi Zhou[1,2], Juanle Wang[1]*, Grigorieva E.A[3]
[1]State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China
[2]China University of Mining and Technology (Beijing), Beijing, China
3 Institute for Complex Analysis of Regional Problems
Russian Academy of Sciences, Far Eastern Branch
Email: zhouyz@lreis.ac.cn, wangjl@igsnrr.ac.cn (*corresponding author), eagrigor@yandex.ru

As a kind of time scale to the assessment of travel climate comfort degree, travel climate comfortable period (TCCP) is of significance to tourism development, such as architectural design of the tourism scenic spot, health of the tourists, and regional tourism development strategy under climate influence etc. Most of studies on TCCP generally took month-scale as the time granularity, which was too long to precisely chart the intra- or inter- regional differences. TCCP spatial and temporal characteristics of Northeast China from 1981 to 2010 in day-scale are described. Based on the daily meteorological data from 98 basic weather stations in Northeast China, including Heilongjiang province, Jilin province, and Liaoning province, this paper made use of Temperature Humidity Index and Wind Chill Index, and built the compound model based on them to assess the climate comfortableness of this area in the past 30 years since the 1980s. This study indicates the average annual and seasonal TCCP and its spatial patterns in Northeast China. The research results can provide the basic cognition and important reference of the travel health guarantee and climate environmental adaption for the tourism development in this area.

Keywords: *travel climate comfortable period, Northeast China, Temperature Humidity Index, Wind Chill Index, tourism development.*

Introduction

The travel climate comfortable degree is one of the biometeorological indices which aims to evacuate travelers' comfort condition under the different climate cases and it is stipulated by the heat exchanging theory between human organisms and the environment [1]. The discrepancy of the index causes the variation of travel climate comfortable period (TCCP) distribution and the seasonal characteristic in the recreation area directly. So it makes critical effect on the architectural design of the scene spot [2], the health of tourists [3] and the development of tourism industry. During the past half century, with the differential region climate response which caused by global warming, the travel climate comfortable degree and period of the different region has varied differently [4]. Acting as the ruler which is able to measure the travel climate comfortable duration, TCCP characterizes the travel climate comfortable degree intuitively and numerically. In the initial survey, a large amount of researchers define TCCP by using the month-scale as the time granularity. However, compared with the method by using the day-scale as the time granularity, the definition is too long to precisely chart the intra- or inter- regional differences of the study area.

The area between China and Russia is extensive and resourceful. Owing to the complexity of the land cover types and the huge span of its longitude and latitude, the climate change makes different impact on the different area in this region. So it is essential to develop the investigation on the spatial-temporal patterns of TCCP totality in this region. This survey choose the north-east region of China which is adjacent to Russia as the study area and try to describe spatial and temporal characteristics of TCCP in Northeast China from 1981 to 2010 based on day-scale method.

Data sources and research methods

The study area of this paper includes Heilongjiang province, Jilin province, and Liaoning province in China. The climate data resource of the area is from China Meteorological Science Data Sharing Service Website (http://cdc.cma.gov.cn/). The data comment includes three kinds of daily ground climate data: air temperature, wind speed and relative humidity which were collected by 98 meteorological datum stations within the study area from 1981 to 2010.

This paper draw lessons from the division method of season in meteorology field. The beginning/end date of TCCP is defined by the rule that the first day of one week in which the temperature and humidity index (THI) and the wind chill index (WCI) are within/out the range of "comfort" threshold. The model expression of THI is shown in (1); the model expression of WCI is shown in (2):

$$THI = t - 0.55(1 - 0.01RH)(t - 14.5) \quad (1)$$

$$WCI = (33 - t)\left(9 + 10.9\sqrt{v}\right) - v \quad (2)$$

where t is air temperature (°C), RH is relative humidity (%), v is wind speed (m s^{-1}).

In this paper, the classification standard of the above indexes is scientifically identified by the meteorological data of Northeast China, and the "comfortable" threshold scope of the study area is further defined. Firstly, the daily WCI values of 98 datum meteorological stations in Northeast China during 1981–2010 are calculated, and the corresponding temperature distribution information of these values in their nine grade division is counted.

According to the comfort period definition of this study, the beginning and end dates of the monthly travel climate comfort period of the Northeast China in recent ten years (2001–2010) are determined and the results of the 10 year comfort period are averaged, the beginning and expire time of the monthly average travel climate comfort period of the city level during 2001–2010 is finally obtained. This time period can be used as the reference time for tourists to carry out tourist activities in the corresponding month.

Spatial pattern characteristics

Based on the combined model strategy and the corresponding comfort threshold criteria, the climate comfort period of 1981–2010 in Northeast China was calculated by the equations (1) and (2). Based on ArcGIS software and spatial interpolation carried out by using the common Kriging interpolation method according to the calculation results, the spatial distribution of annual average TCCP (Figure 1) and quarterly average TCCP (Figure 2) in Northeast China are obtained.

As shown in Figure 1, the annual average

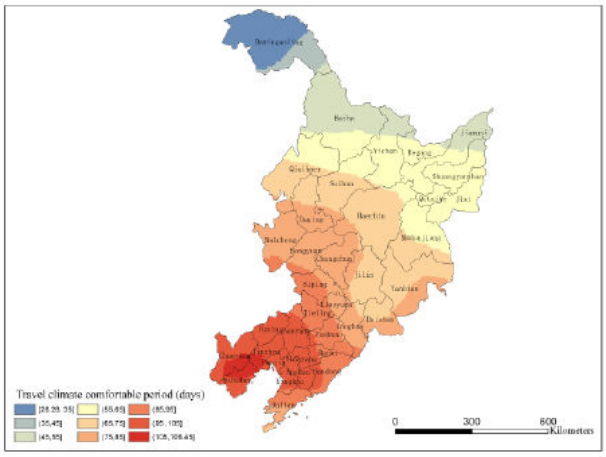

Figure 1. Spatial distribution of the annual average climate comfortable period in Northeast China from 1981 to 2010

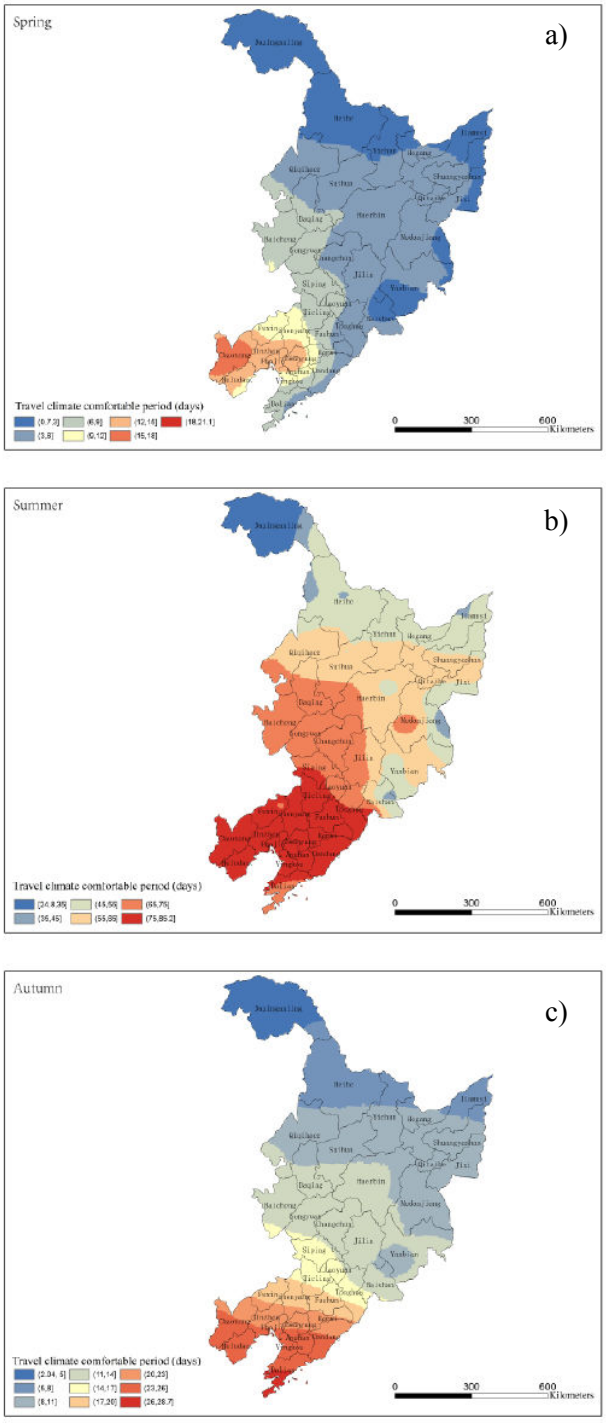

Figure 2. Spatial distribution of the seasonal average climate comfortable period in Northeast China from 1981 to 2010 (a represents Spring, b represents Summer, c represents Autumn)

TCCP in Northeast China has a spatial pattern of "long in southeast and short in northwest", with the longest TCCP in the adjacent area among the cities of Jinzhou, Huludao and Chaoyang in Liaoning province. The TCCP lasts 106.45 days. The shortest TCCP occurs in Greater Khingan Range, Heilongjiang Province, and the duration is 26.28 days. It can be clearly seen that the annual TCCP in Northeast China has gradually increased with the decrease of the latitude.

As shown in Figure 2(a),during the spring season, the TCCP of Northeast China generally maintained a similar spatial pattern with the annual average TCCP. The TCCP in Northeast China is generally low in spring and the longest comfort period is 28.7 days. It appears in the area under the jurisdiction of Chaoyang in Liaoning province. The shortest comfort period is only 0.7 days, and it still appears in Greater Khingan Range, Heilongjiang province. It indicates that the climate comfort condition in Northeast China is not optimistic in spring.

As shown in Figure 2(b), for the visitors to the study area, the summer of Northeast China is the most ideal season for the four seasons in this region, of which most of the cities in Liaoning and some cities in southern Jilin are within the range of 75~85.2 days, which are very suitable for tourists to travel. With the highest latitude in the region, Greater Khingan Range have the shortest TCCP, the interval lasts 24.8 days. However, compared with other seasons, the summer TCCP in this area has increased significantly.

As shown in Figure 2(c), during the autumn season, the TCCP in Northeast China is almost as the same condition as that in spring. The longest TCCP occurs in the area under the jurisdiction of Dalian, Liaoning province. The duration of the comfortable period is 28.7 days. The shortest TCCP still occurs in Greater Khingan Range, Heilongjiang province. The duration of comfortable period is 2.04 days.

According to the THI and WCI combined model strategy used in this paper, it is calculated that the whole region in Northeast China have no comfortable period in winter.

Law of historical evolution

Based on the annual and seasonal TCCP which are calculated by 98 datum meteorological stations in Northeast China from 1981 to 2010, the differences of TCCP mean values between 1996–2010 (latter 15 years) and 1981–1995 (former 15 years) is calculated in the whole region (hereinafter referred to as the two phase difference). On the one hand, the annual and seasonal differences in two phases have been counted. On the other hand, the spatial interpolation of the two phase difference is carried out by using the ArcGIS software.

The research shows that:

(1) The average annual TCCP in Northeast China from 1996 to 2010, compared with the former phase, shows the time evolution law of "little change in the north and South, more change in the middle". The most TCCP increased area locates in the cities of Jiamusi, Shuangyashan and Jixi in Heilongjiang Province, and the later period of comfort increased by 11.26 days compared with the previous phase. The most reduced areas of TCCP were found in parts of Western Liaoning and Western Greater Khingan Range, Heilongjiang province, and the later phase of comfort decreased by 2.4 days compared with the previous phase.

(2) During 1996–2010, the TCCP of Northeast China in spring is generally lower than that in the previous phase, of which the areas with the most descending of the TCCP occur in the 7 cities in the central Liaoning Province, and the latter phase is reduced by 4.47 days compared with the previous phase. In the northern part of Heilongjiang, the eastern part of Jilin province and the western part of Liaoning, TCCP in the later phase has slightly improved, the largest increase of which is 1.47 days.

(3) In summer, the time evolution of TCCP in Northeast China is similar to that of the annual TCCP. The TCCP of the border area among the cities of Jiamusi, Shuangyashan and Jixi in Heilongjiang has the largest increase (12.84 days) in 1996-2010 compared with the years in 1981–1995. There was a slight decrease of TCCP in some parts of Dalian and Huludao, Liaoning Province, with a maximum decrease of 0.9 days.

(4) During the 1996–2010, the TCCP in the southern cities of the Northeast China is higher than that of the previous phase. The largest increase area appears in the three seashore cities: Yingkou, Dalian and Panjin in Liaoning province with the increased 11.28 days. In the northern part of Greater Khingan Range, Heilongjiang, there was a slight decrease in the TCCP compared with the years of 1981–1995, with a maximum decrease of 2.39 days.

Conclusions

Based on the daily meteorological data of 98 datum meteorological stations in Northeast China for 1981–2010 years, this paper makes use of improved wind cold index (WCI) and temperature humidity index (THI) combination model strategy to analyze the spatial pattern and time evolution of TCCP in the northeast of China for last 30 years. The result shows that:

(1) According to the combined model of THI and WCL and the actual climate conditions in Northeast China, the annual and seasonal TCCP of the re-

gion is about 66.4 days, of which the longest (41.68 days) in summer, the spring and autumn (9.35 days and 15.37 days), and the shortest (0 days) in winter. The proportion of summer comfort period is about two times than that of the two seasons of spring and autumn.

(2) The seasonal climatic comfort period of the annual average and the two quarter of the spring and autumn period are presented as the spatial pattern of "long in southeast and short in northwest". The high value area of the summer climate comfortable period is mainly distributed in the southern coastal cities of the region. The temperate monsoon climate and the corresponding seasonal factors become the main influence of the longer comfort period in these cities. In winter, the research area has no TCCP. So the tourists, especially the old and the people in poor physical conditions, are advised to reduce travel time in the area. If necessary, essential precautions and cold-proof measures are needed.

(3) From the general point of view, the annual average TCCP in Northeast China has increased for nearly 30 years (1981–2010), and it has increased about 6.37 days in the last 15 years, of which the two quarter of summer and autumn have contributed about 90%. Compared with the previous phase, TCCP of the study area in spring is lower than that in the previous phase, but the decrease is relatively small, and the change of TCCP in this area is relatively stable.

Acknowledgement

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FACTOR TEMPORARY FORECAST OF SOCIALLY SIGNIFICANT MORBIDITY IN PRIMORSKY KRAI

Svetlana A. Lozovskaya[1]*, Gurami Sh. Tsitsiashvili[2], Natalia G. Stepanko[1], Evgeniy I. Bolotin[1], ElenaV. Izergina[1], Artur R. Pogorelov[1]
[1]Pacific Geographical Institute Far Eastern Branch Russian Academy of Sciences, Vladivostok, Russia
[2]Institute of Applied Mathematics Far Eastern Branch Russian Academy of Sciences, Vladivostok, Russia
Email: lana.prima12@mail.ru (*corresponding author)

At present, the problem of climate change and its impact on human health has become one of the central issues in the field of anthropoecology. The aim of this work was to analyze the influence of climatic factors on the socially significant pathology of the population in regions of Primorsky Krai. The main research method was "time factor forecasting". The "factor" approach proposed by the authors is based on the idea of predicting not specific absolute indicators, but morbidity level that could be higher or equal to some critical value given by the researcher. This problem was solved by the original algorithm for interval pattern recognition. Based on this method, the results of temporary factor forecasting of the critical levels for 7 indicators of socially significant morbidity using four climatic, four socio-economic and one environmental factor, are presented. It is shown climatic factors basically are satisfactory and have a high quality for the forecast, while the socioeconomic and ecological factors are mostly unsatisfactory. At the same time, climatic indicators in combination with environmental and socio-economic have yielded significantly better forecasting results than each single factor. The quality of the forecast significantly increases as a result of the combined impact of factors with different character, and climatic factors enhance the impact of certain environmental and socio-economic factors (the phenomenon of synergism). Thus, the proposed method allows predicting epidemiological situation for the following years based on a combination of various environmental factors.

***Keywords**: morbidity, factor approach, climate, forecasting, Primorsky Krai.*

Introduction

Reducing the negative impact of environmental changes on public health is "a guarantee of sustainable social and economic development of the country, fulfillment of social obligations, improving the quality of life" [3]. The modern period continues to be characterized by a very tense epidemic situation in a vast complex of not only infectious but also somatic diseases both at the Russian Far East and in Russia as a whole [1, 7]. On the one hand, this is due to the current unstable socio-economic and environmental conditions, and on the other hand, to the natural dynamics of natural processes. The level of public health continues to decline, which ultimately will have a negative impact on demographic reproduction.

Recently, the problem of the influence of climate and its fluctuations on human health has become one of the central. The issue of linking the health of the population and the climate as an integral part of the environment is the main one in shaping the projections of the future life of a person. This is determined by the fact that significant climate changes in combination with various factors of the human environment significantly change the social and economic conditions of different territories, directly affecting the quality of life of the population. At the same time, studying the features of climate interaction and human health is extremely difficult, since it is connected with the analysis of relationships and dependencies in complex multi-component open anthropoecological systems.

The natural, ecological, socio-economic components of the habitat of the population of human being in the regions of the Russian Far East, interacting with each other, can give different spectra and levels of regional differences in the structure of morbidity. This implies a systematic approach to studying changes in public health, allowing more accurate forecasting of risks and opportunities for their reduction for public health.

The problems of increasing environmental pollution are mostly universal, but some of them have regional differences, due to geographical peculiarities and specificity of local production. Assessment of the importance of man-made pollution on health indicators is more objective, because integrally takes into account the influence of all of them, including unidentified pol-

lutants, their complex and combined effects with other environmental factors on human body.

The purpose of this work was to study the effect of a complex of climatic and environmental factors on some indicators of socially significant pathologies in the population of model areas of Primorsky Krai, as well as testing the original method of factorial temporal prediction for the purposes of forecasting socially significant morbidity.

Materials and methods

The information base for the analysis was the statistical data [4, 5, 8–10] on the dynamics of 7 indices of socially significant morbidity indices in 2000–2015 (endocrine diseases, nutritional and metabolic disorders, mental and behavioral disorders, diseases of the nervous system, diseases of the circulatory system, neoplasms, musculoskeletal system diseases, active tuberculosis) in 10 administrative-territorial units of Primorsky Krai (Vladivostok, Dalnerechensk, Dalnegorsk, Ussuriysk, Lazovsky, Pogranichny, Terney, Khasansky, Spassky, Pozharsky districts). Five influencing factors were used: long-term data on mean air temperature and air pressure in January and July at 10 weather stations located in 10 municipal districts (MD) of the province and one environmental factor – average annual emission of pollutants into the air by industrial enterprises.

Method of time factor forecasting was used. The proposed "factor" approach is based on the idea of forecasting not specific absolute indicators, but morbidity levels that could be higher or equal to some critical value given by the researcher. This problem was solved by the original algorithm for interval pattern recognition [2]. The quality of prediction by factors was calculated by using the ratio of the number of positive results obtained from the links of all incidence rates with this factor in all the study areas to the total number of results obtained (equal to or greater than 0.7). The universality the algorithm proposed allowed carrying out numerous computational experiments with the accumulated array of reliable data, which determines its significant reserve for use in various fields of knowledge.

Results and Discussion

Public health is significantly affected by the ecological state of the environment. Nikitin et al. [6] calculate longevity indices, based on the CSO data, which, in turn, are a definite reflection of the environmental situation in the place of residence. The lowest index is 5.20‰ for the Russian Far East, which is about half the mean national value, and 4.66‰ for Primorsky Krai. The ecological state of the territory, which is the result of existing production and natural relations, can be considered as one of the limitations for the functioning the most influential enterprise or the entire territorial-economic structure because it has negative economic and social effects, and also negatively affects the health of the population.

The analysis of ecological and economic indicators of industrial and natural relations in Primorsky Krai showed that the main share in the formation of the ecological state of the region is caused by the pollution of water and atmosphere, which are calculated from the ratio of pollutants and total emissions to the atmosphere and the ratio of contaminated and general wastewater discharges.

According to the assessment of production and natural relations in the region, the municipal district (MD) Pozharsky, Dalnegorsky, Mikhailovsky, Shkotovsky (Figure 1) received a restriction on the further functioning of the existing territorial and economic structure. It should be mentioned that although Pozharsky region is fully classified as "L", with all the parameters under consideration, only the western part of the area where the coal industry and the energy sector are concentrated, should be considered.

Given the low environmental friendliness of industrial and natural relations in Primorsky Krai at the present time, it can be assumed that with the im-

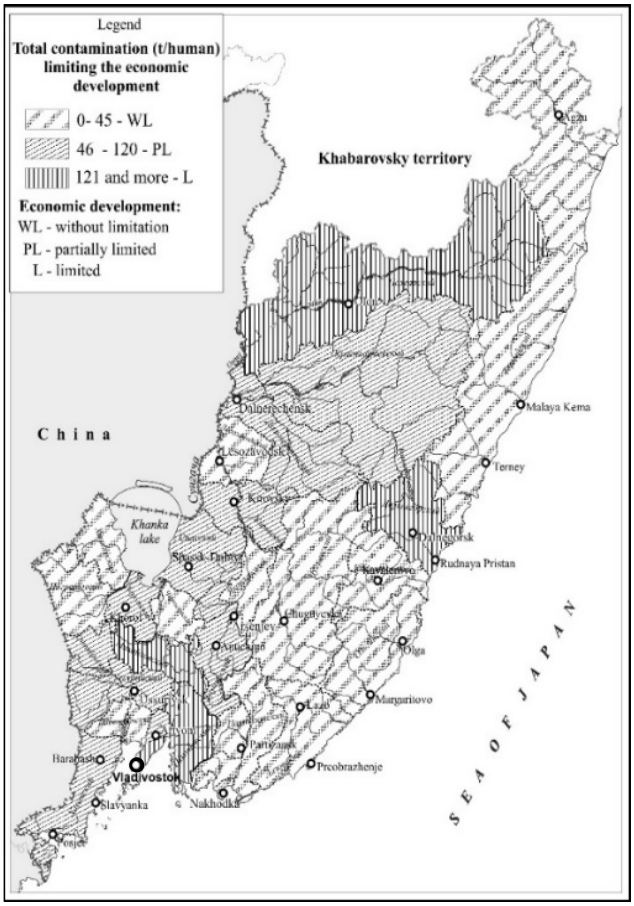

Figure 1. Pollution of Primorsky Krai

plementation of new investment projects, the industrial impact on the environment will increase. This will entail a worsening of social, and then ecological conditions in these territories (Figure 2). When determining the degree of increase in anthropogenic load, we took into account: the type of economic activity of the project, the number of projects of a particular type of activity, the specific impact, the "chain" of man-made impact (i.e., what and how many components of the environment, including humans, will be influenced, directly or indirectly).

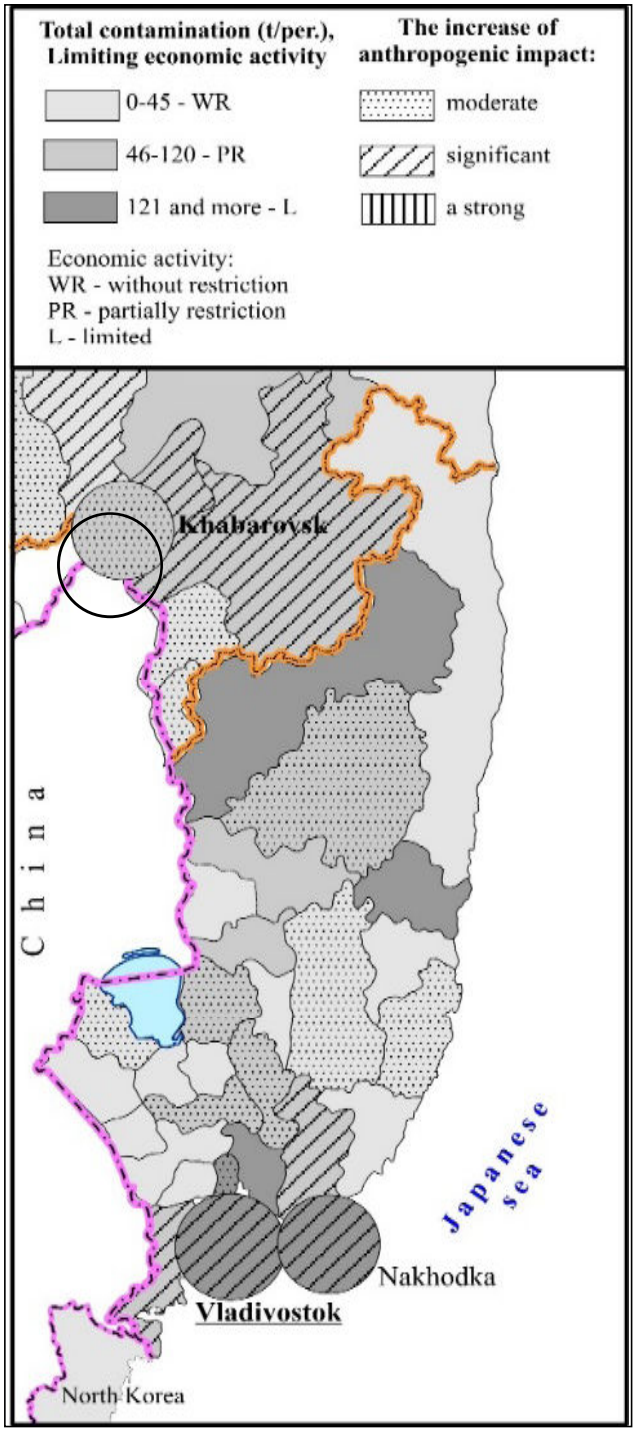

Figure 2. Increase of anthropogenic load on environment in connection with the implementation of investment projects

It should be noted that the functioning of the profile types of production is almost stable. And since natural and resource potential is sufficient and diverse for a long-term perspective of industry production in Pozharsky, Dalnegorsky and Mikhailovsky regions, and there is a production base for the utilization of nuclear submarines in Shkotovsky district, we may assume there will be no structural restructuring of production in the allocated areas. This means that man-made pressure will intensify, which can lead to irreversible consequences of changes in the natural environment, and, most important, to a significant deterioration in the living conditions of the population. Features of the composition and dynamics of anthropogenic air pollution in various areas of Primorsky Krai in combination with the monsoon climate, contributed to the emergence of new effects on human health.

Using method of time factor forecasting, it is possible to forecast critical levels for 7 socially significant indicators of morbidity in 10 districts of Primorye per year (from 2000 to 2016) with the help of climatic and environmental factors of the environment (Table 1–3). In the forecasting results Tables, cells with a prediction quality greater than 0.7, filled with us as an acceptable quality of the forecast for the next year, determined by exceeding the critical levels of morbidity, are painted in gray.

Table 1 presents the quality of forecast from the present for the next year on the pollution of the atmosphere by emissions from industrial enterprises. It is estimated that the quality of the positive prognosis (the probability of exceeding critical incidence rates) for this factor for the next year is low and is only 0.15 (or 15.0%).

Nevertheless, this factor in some areas of the province (Dalnerechensk, Dalnegorsk, Pogranichny, Khasansky, Pozharsky Districts) can act as a forecast and reach critical levels of incidence of active tuberculosis, mental disorders and other diseases (Table 1). In the Dalnerechensky District, for example, a positive prognosis for tuberculosis and mental disorders reaches 100% (1.000). In the Dalnerechensky District, for example, a positive prognosis for tuberculosis and mental disorders reaches 100% (1.000).

With the help of the presented method, it is possible to obtain a higher quality of the forecast by unrestricted search or a combination of forecasting options, if you manipulate the quantity and "nature" of the influencing factors. So, when forecasting for four climatic factors (Table 2), the quality of the positive forecast for the next year will increase sharply to 0.8

Table 1

Temporal factor forecasting of critical levels of socially significant morbidity with the use of an environmental factor (air pollution by emissions from industrial enterprises)

City, municipal district / incidence	Tuberculosis	Neoplasms	Diseases of the endocrine system	Mental disorders	Diseases of the circulatory system	Diseases of the musculoskeletal system	Diseases of the nervous system
Vladivostok	0.625	0.357	0.417	0.455	0.556	0.625	0.500
Dalnerechensk	**1.000**	0.455	0.455	**1.000**	0.714	0.625	0.385
Dalnegorsk	0.833	0.385	0.385	0.417	0.556	0.500	0.556
Ussuriysk	0.500	0.385	0.500	0.417	0.500	0.625	0.500
Lazovsky MD	0.417	0.625	0.625	0.556	0.625	0.556	0.714
Pogranichny MD	0.714	0.417	0.417	0.714	0.500	0.455	0.714
Terneisky MD	0.500	0.385	0.385	0.417	0.556	0.417	0.625
Hasan MD	0.833	0.625	0.417	0.625	0.455	0.417	0.455
Spassky MD	0.417	0.385	0.385	0.500	0.455	0.357	0.417
Pozharsky MD	0.417	0.385	0.385	0.455	0.833	0.714	0.500

Table 2

Temporal factorial prediction of critical levels of socially significant morbidity with the use of climatic factors (mean air temperature and air pressure in January and July)

City, municipal district / incidence	Tuberculosis	Neoplasms	Diseases of the endocrine system	Mental disorders	Diseases of the circulatory system	Diseases of the musculoskeletal system	Diseases of the nervous system
Vladivostok	0.714	0.833	**1.000**	**1.000**	0.714	0.833	0.625
Dalnerechensk	0.833	0.556	0.833	**1.000**	**1.000**	**1.000**	0.833
Dalnegorsk	**1.000**	**1.000**	0.833	0.556	**1.000**	0.833	0.833
Ussuriysk	**1.000**	**1.000**	0.500	0.833	0.714	0.833	**1.000**
Lazovsky MD	0.625	**1.000**	**1.000**	0.833	0.833	**1.000**	0.714
Pogranichny MD	0.833	**1.000**	0.417	0.714	0.833	0.833	0.714
Terneisky MD	**1.000**	0.833	**1.000**	0.714	**1.000**	0.833	0.833
Hasan MD	0.833	0.833	0.833	0.625	0.714	0.714	0.833
Spassky MD	0.833	0.625	**1.000**	0.714	0.714	0.714	**1.000**
Pozharsky MD	0.833	**1.000**	0.833	0.833	0.833	0.833	0.833

(or 80.9%). Moreover, in some regions, the quality of the prognosis will reach even 100% for individual morbidity indicators (1.0).

When predicting the achievement of critical levels of morbidity in the next year by five factors (Table 3), the quality of the positive forecast increased even more and amounted to 0.9 (90.4%).

Thus, forecast with only one environmental factor gives a significantly lower quality of the forecast than with four climatic factors. While climatic factors show mainly satisfactory and high quality forecast, the ecological one is mostly unsatisfactory. Climatic indicators in combination with environmental ones have yielded significantly better forecasting results than a single factor. The quality of the forecast significantly increases as a result of the combined impact of factors of different nature, and climatic factors can enhance the impact of some environmental (synergism phenome-

Table 3

Temporal factor forecasting of critical levels of socially significant morbidity with simultaneous use of environmental factors (mean air temperature and air pressure in January and July plus air pollution from industrial enterprises)

City, municipal district / incidence	Tuberculosis	Neoplasms	Diseases of the endocrine system	Mental disorders	Diseases of the circulatory system	Diseases of the musculoskeletal system	Diseases of the nervous system
Vladivostok	0.833	0.833	**1.000**	**1.000**	0.833	**1.000**	0.714
Dalnerechensk	**1.000**	0.625	0.833	**1.000**	**1.000**	**1.000**	0.833
Dalnegorsk	**1.000**	**1.000**	**1.000**	0.625	**1.000**	0.833	0.833
Ussuriysk	**1.000**	**1.000**	0.556	0.833	0.714	0.833	**1.000**
Lazovsky MD	0.714	**1.000**	**1.000**	0.833	**1.000**	**1.000**	0.833
Pogranichny MD	**1.000**	**1.000**	**1.000**	**1.000**	0.833	0.833	0.833
Terneisky MD	**1.000**	0.833	0.833	0.714	**1.000**	0.833	0.833
Hasan MD	**1.000**	0.833	0.833	0.714	0.714	0.714	0.833
Spassky MD	0.833	0.625	**1.000**	0.714	0.833	0.714	**1.000**
Pozharsky MD	0.833	**1.000**	**1.000**	**1.000**	0.833	**1.000**	0.833

non) and lead to increased levels of morbidity in some areas. At the same time, existing relationships between the elements of these complex anthropoecological systems can be both integrative and competitive, which obviously affects the nature of the epidemic process for specific diseases.

Thus, as a result of the study, a significant amount of predicted data was obtained for 7 indicators of socially significant diseases in 10 districts of Primorsky Krai for the period 2000-2015 (Table 1). The proposed method allows predicting the epidemiological situation for the next year using various environmental factors with sufficient accuracy.

Increasing quantity of factors increases the quality of recognition. The Index of Quality of Recognition (IQR) used in the work can be considered as an analog of the multiple correlation coefficient between the predicted and operating factors, the magnitude of which can be judged by the closeness of the connection between the index of individual diseases and affecting factors. The maximum IQR (1.0) means 100% recognition quality. In order to verify the results of forecasting, it is necessary to compare the critical and true levels of morbidity in the following years.

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WEATHER DEPENDENCE OF PATIENTS WITH RESPIRATORY PATHOLOGY AT THE SOUTH OF PRIMORSKY KRAI

Tatiyana I. Vitkina[1]*, Lyudmila V. Veremchuk[1], Elena A. Grigorieva[2], Tatiyana A. Gvozdenko[1]
[1]Vladivostok Branch of Federal State Budgetary Science Institution «Far Eastern Scientific Centre of Physiology and Pathology of Respiration» – Institute of Medical Climatology and Rehabilitation Treatment (Vladivostok branch of FESCPPR – IMCRT), Vladivostok, Russia
[2]Institute for Complex Analysis of Regional Problems Far Eastern Branch Russian Academy of Sciences (ICARP FEB RAS), Birobidzhan, Russia
Email: tash30@mail.ru (*corresponding author)

Climato-physiological reactions can be considered as favorable or adequate one, when irregular reactions of functional systems initiate autoregulatory processes returning the system to optimal functioning. The weather dependence is an ability of an organism to respond to changes in particular weather parameter and a complex of weather factors (atmospheric pressure, temperature, wind, etc.). The climatic factors mainly exposure to the skin and the mucous membranes of the upper respiratory tract; the respiratory system changes induced by the contrasting climate can be the result of meteophysiological processes and meteopathic reactions. Disadaptation in patients with respiratory diseases occurs more often and is more severe than in healthy people. The aim of the current study is to define the weather dependence degree of external respiration function of patients with bronchopulmonary pathology in the south of Primorsky Krai, characterized by the monsoon climate with negative effect on human health.

Keywords: *weather dependence, external respiration function, bronchopulmonary pathology.*

Introduction

Chronic respiratory diseases are among the leading causes of morbidity and mortality worldwide [4]. The etiology of respiratory diseases is largely determined by the influence of weather conditions. Normally, physiological processes in human body as a whole adapt to weather changes. But the course of respiratory diseases is determined largely by weather: directly through an impact on the respiratory tract or indirectly through a change in the intensity and nature of immunometabolic processes [2, 3, 9, 11, 13, 14]. However, the mechanisms of weather influence have not been sufficiently studied. Literature review shows conflicting results related to both different research approaches and regional characteristics of heterogeneous weather conditions influencing human body. Therefore, the study of the nature of the response of patients with a respiratory disease to weather conditions is important problem.

The weather factors influence on external respiration function (ERF) by a direct action on the mucous membranes of the respiratory tract; the study of ERF is essential for the diagnosis of violations in lung ventilation as a response to the external stress [12].

Oxidative stress plays a key role in the pathogenesis of chronic lung diseases. Reactive oxygen species can serve as triggers of inflammation process both directly and through the formation of lipid peroxidation (LPO) products. Oxidative stress has important consequences for the respiratory system and the body as a whole [1, 7, 10]. However, nowadays there is practically no information about the impact of weather on the parameters of lipid peroxidation and antioxidant protection in patients with respiratory pathology.

The aim of the current study is to identify the mechanism of formation of meteopathic reaction in patients with respiratory diseases under the influence of the monsoon climate at the Russian Far East, characterized by contrasting changes in meteorological parameters with specific response in patient with respiratory pathology.

Materials and Methods

The subjects examined during period from 2012 to 2017 were 146 residents of Vladivostok: chronic catarrhal non-obstructive bronchitis (CCNOB) was diagnosed in 29 subjects, controlled asthma – in 51 subjects, and uncontrolled asthma – in 39 subjects. The control group included 27 healthy volunteers.

The study of ERF was carried out by *spirography* (*12 parameters*), characterizing the type of lung ventilation disorder, degree and reversibility of

bronchial obstruction; and by *body plethismography* (*8 parameters*), describing static lung volumes and bronchial resistance.

The system "lipid peroxidation–antioxidant defense" (the LPO-AOD system) is analyzed to understand the process of cell energy provision, that acts as a key trigger mechanism in chemical modification of cell membranes. The LPO system includes two parameters (malonic dialdehyde – MDA, malonic dialdehyde / antioxidant activity – MDA/AOA); the AOD system integrates five parameters (antioxidant activity – AOA, superoxide dismutase – SOD, glutathione peroxidase – GP, glutathione reductase – GR and reduced glutathione – GSH).

The study involves weather data (2012–2017) provided by Primorsky Office for Hydrometeorology and Environmental Monitoring [8, 15]. Standard meteorological parameters: air temperature and humidity, dew point temperature, atmospheric pressure, wind speed and direction, precipitation, atmospheric phenomena, apparent temperature, are used. The concept of "weather complex" is introduced, showing simultaneous influence of 9 weather parameters.

To estimate how respiratory system depends on weather changes, analysis was carried out for: a) the ERF response on the examination day (actual weather complex) and weather complex on 1 and 2 days after the examination; b) the LPO–AOD response on weather complex 1 and 2 days before the examination. The meteopathic reaction of a human body to climate is estimated in two stages: 1) direct influence on ERF; 2) indirect effect on the LPO–AOD system. Methods of the study at the first and second stages were different.

The study how weather conditions affect ERF was conducted based on the assessment of *inter-systemic* (P_{inter}) and *intra-systemic* relations (P_{intra}). P_{inter} described the intensity of response of the ERF system to the influence of weather complex by 3 points (on the examination day, 1 and 2 days **after** the examination). These data determine the respiratory organs sensitivity to changes in weather conditions at different level of respiratory diseases severity. The calculation of *direct* influence of weather conditions on ERF was conducted in two ways: 1) estimation of P_{inter}% according to diagnostic system of ERF (spirography, body plethismography) and depending on the severity of respiratory disease; 2) the assessment of P_{inter}% characterizing compensatory reaction of ERF to the influence of weather complex on the examination day, 1 and 2 days *after* the examination.

To calculate inter-systemic and intra-systemic relations, the module "Multiple correlation" (STATISTICA8) is used. The pair correlations (r) with statistical significance $p<0.05$ are summed and divided by the expected maximum sum of the correlation relations $R=1.0$ to select percent of active relations from total sum of correlation relations.

Thus, the sum of r_{inter} evaluates the activity of the respiratory response (P_{inter}) of ERF on the effect of weather complex, and the sum of r_{intra} indicates the degree of functional strain (P_{intra}) of the particular ERF systems depending on severity of respiratory diseases and weather.

The response of the biochemical blood parameters to the weather impact is estimated by the *indirect* influence of weather conditions on the LPO-AOD system with time lag 1 and 2 days. The module "Multiple regression" in the program STATISTICA8 is used for calculating the "response" of subsystems and particular indicators of the LPO-AOD system (R_{regres}).

Results and Discussion

Differences of P_{intra}% represent changes in ventilatory lung capacity depending on the disease severity. Patients with CCNOB have minimal changes in ERF (P_{intra}=26–28%) compared to control group (P_{intra}=23–25%). A significant increment of P_{intra} (1.5–2 times) indicates the most marked violations of ventilatory lung capacity in asthma (P_{intra}=39–43%).

The activity of ERF response (P_{inter}%, $p<0.05$) under the direct influence of weather complex differed depending on the severity of respiratory diseases. For instance, the total indices ΣP_{inter} (Body + Spir) in healthy subjects were 7.8% (on the examination day), 8.9% (on 1 day after the examination) and 9.5% (on 2 days **after** the examination). These data demonstrate high compensatory capacity of a healthy body. However, the weather on the examination day (ΣP_{inter}=7,8%) reduces the adaptive potential of the respiratory system even in healthy subjects, indicating negative influence of the monsoon climate.

The analysis of the total ΣP_{inter} in pathologies showed a clear dependence of the decrease in adaptive capabilities of ERF, depending on the severity of the respiratory diseases (ΣP_{inter}=1.1-5.7%). We assume that the influence of the monsoon climate causes a sharp decrease in the compensatory reaction (P_{inter}) in respiratory diseases characterized by a high intrasystem tension of ERF (P_{intra} in asthma).

The ERF in patients with respiratory diseases actively react to changes in weather 1 day **after** the examination, expressed mostly in patients with asthma (ΣP_{inter}=1.1%). Slight increase in weather sensitivity (ΣP_{inter}=5.5%) was observed in patients with CCNOB compared to the examination day (ΣP_{inter}=5.8%).

The analysis of ΣP_{inter} values 2 days after the

examination shows that weather sensitivity in patients with CCNOB increases (ΣP_{inter}=3.8%) compared to data of 1 day **after** the examination (ΣP_{inter}=5.5%). Perhaps it is due to the continuous and active reaction of the respiratory organs to the external environment in this pathology. However, a completely different reaction is observed in patients with asthma, when total parameter (Body + Spir) ΣP_{inter} is low enough (ΣP_{inter}=1.1%) one day **after** the examination, and rises to 2.7% two days **after** the examination, that can be explained by inertial character of respiratory system to weather change in asthma.

The *indirect* effect of weather on human body was analyzed by the response of the parameters of the LPO–AOD system (R_{regres}). This system is involved in the process of providing energy for cells and is the most important trigger for the chemical modification of cell membranes [16]. The dependent variable «*y*» was the component of the LPO–AOD system (prooxidant system – MDA, MDA/AOA; antioxidant system – AOA, SOD, GSH, GP, GR). The independent variable «*x*» was the weather parameter.

The study shows there is no pronounced response of peroxidation parameters to weather in healthy subjects and, accordingly, there is no need to induce compensatory antioxidant processes in them. The LPO–AOD system of patients with respiratory pathologies responded quite actively to changes in weather complex in 1 and 2 days before the examination (R_{regres}=0.42–0.50) compared to the actual weather complex (R_{regres}=0.31–0.38) (Figure). The high reaction causes peroxidative process and induces a fairly rapid response of the system to weather within 1 or 2 days. The integral criterion characterizing the LPO–AOD balance (MDA/AOA) is the best to demonstrate the reaction of the human body to weather factors. The enzymes of the AOD system (GSH, GP and CO), which are involved to remove lipid hydroperoxides, hydrogen peroxide, and to reduce oxidized glutathione, have a significant importance for the response of this system. GP and GR as key factors of the maintaining the oxidative cell balance, play the most important role in the formation of the compensatory response to weather. The activation of the glutathione unit in AOD system is aimed at interrupting the chain reaction of lipid oxidation to inhibit stress-induced accumulation of LPO products.

The respiratory pathology is accompanied by the development of the systemic oxidative stress. One of the reasons is the disregulation of the AOD system as the result of polymorphism of gene encoding the AOD enzymes. The intensification of oxidative stress has important implications for the course of the respiratory diseases. They include increased neutrophil sequestration into the lungs, oxidative inactivation of antiproteases and surface-active agents, mucus hypersecretion, destruction / remodeling of extracellular matrix and apoptosis. The oxidative stress leads to direct or indirect damage of key cellular components, such as lipids, proteins and nucleic acids, and also inhibits DNA repair [5, 6, 17].

Conclusion

The impact of the monsoon climate on patients with the respiratory diseases induces the complex mechanism of the response of the human body and leads to the formation of meteopathic reactions that actively influence the most open ERF system and indirectly – LPO–AOD system.

The strain of the ERF system of patients living in the monsoon climate is intensified depending on the

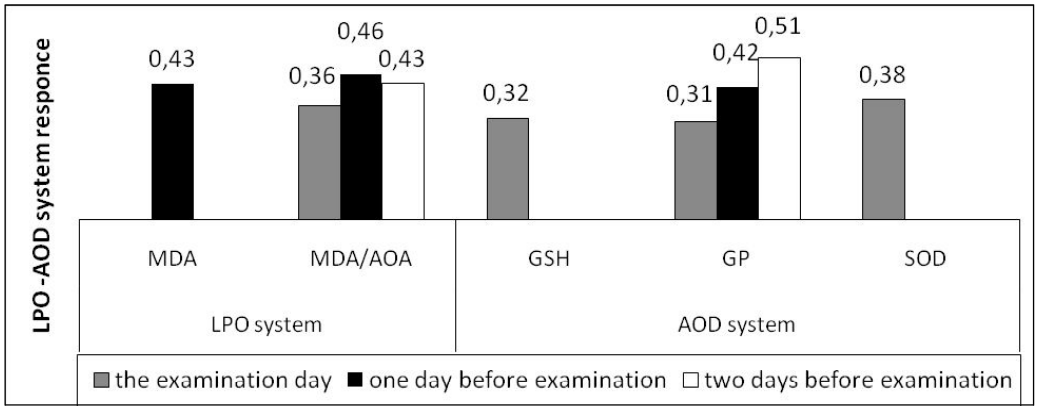

Figure. Response of the LPO-AOD system to the influence of weather complex (R_{regres})

disease severity. At the same time the adaptive-compensatory reaction of ERF to the influence of weather complex decreases depending on the disease severity and, as a result, the pathogenic process of weather dependence and weather sensitivity is formed. The effect of climate on the metabolic parameters of blood makes a relatively equal contribution to the meteopathic reaction of LPO-AOD system of glutathione-dependent antioxidant enzymes (actual weather complex, weather complex before 1 and 2 days). This process can be regarded as an increase in physiological strain by a change of the adaptive mechanisms at all stages of the development of weather dependence. The impact of the weather complex on human body acts on ERF primarily, while the response of metabolic parameters is manifested with a time lag of 1–2 days. Finally, the monsoon climate creates an additional load on both respiratory system and systems that ensure the peroxidation balance forming prerequisites for worsening of respiratory pathology.

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CLIMATE AND CHILDREN WITH BRONCHIAL ASTHMA: CASE STUDY FOR THE RUSSIAN FAR EAST

Elena A. Grigorieva[1], Evgeniy N. Suprun[2, 3]*
[1]Institute for Complex Analysis of Regional Problems, FEB RAS, Birobidzhan, Russia;
[2]Institute for Maternal and Child Health, Khabarovsk, Russia;
[3]Far Eastern State Medical University, Khabarovsk, Russia,
Email: eagrigor@yandex.ru, evg-suprun@yandex.ru (*corresponding author)

Bronchial asthma (BA) continuously increases during the last century, and to date, has reached 15% of the world's child population. Respiratory system and bronchial asthma morbidity are the first in the list of climate-sensitive diseases, and children compound a climate-high-risk group of the population. In recent years, there has been a steady growth of BA among children and teenagers of the Khabarovsk Krai, Russia; among teenagers, this number has doubled in the last ten years. The aim of the current study is to carry a comprehensive analysis covering climatic factors for bronchial asthma in children and teenagers, at the southern part of the Russian Far East (FE). The study area is located in monsoon climate of temperate latitudes characterized by extreme annual air temperature amplitude, with cold Siberian winter and tropically hot and sultry summer. Assessment of weather impact on children with BA in Khabarovsk, administrative center of the FE, for period 2013–2014 shows that the BA visits have a seasonal regime with peaks in spring (March – April) and in autumn – early winter (November – December), when day-to-day changes in temperature are large, and in summer (July) due to a large number of allergens (flowering plant-allergens), when various allergic diseases exacerbate. At the same time, huge peaks in BA visits have been found in November, 2013 and in April, 2014, that can be estimated as consequences of catastrophic flooding at the Amur River in August-September, 2013.

Keywords: *bronchial asthma, children and teenagers, monsoon climate, air temperature, flooding, Khabarovsk.*

Introduction

Respiratory diseases in children and teenagers have the highest rate in the structure of morbidity in Russia as a whole, and at the Far East (FE), being a leading problem in the public health system [9]. Bronchial asthma (BA) is the most common respiratory chronic disease in children, the prevalence of which has increased significantly in recent years. According to official statistics, about 15% of children in Russia suffer from BA, but the real number is much higher, especially at the FE [8]. Undeclared and misdiagnosed cases, inadequate or lost treatment lead to an increase in child disability and fatal outcomes.

The southern part of the Russian Far East is located in the area with monsoon climate of temperate latitudes, characterized by severe cold Siberian winter and hot humid, tropically sultry summer. Severe day-to-day changes in temperature and air pressure, typical to the transitional seasons, lead to changes in the content of oxygen in the air, having negative impact on people with bronchopulmonary disease, especially children [11]. A weak thermoregulatory mechanism of the child's body should undergo seasonal changes, when chronic diseases, including BA, can aggravate, and is particularly vulnerable to seasonal illnesses, primarily respiratory viral infections [13, 16].

The area close to the Amur River is flooded regularly; as a result conditions favorable for uncontrolled spreading of fungal allergens outside and inside, in wet and poorly ventilated houses, are formed. Catastrophic flood during August – September, 2013 was unprecedentedly powerful and protracted with huge economic damage. Another problem in warm season is a large number of allergens (flowering period of allergen plants), triggering exacerbation of various allergic diseases, including asthma.

The aim of the current work is to identify weather factors of bronchial asthma evolution in children and teenagers in Khabarovsk before and after the 2013-year flood on the Amur River.

Materials and Methods

Weather data used was everyday mean air temperature at weather station in Khabarovsk (WMO index 31735) for period from January, 01, 2013, till December, 31, 2014, available from the Russian Research Institute of Hydrometeorological Information – World Data Centre located in Obninsk, Russia (http://meteo.ru/data). The mean daily air temperature was calculated using 3-hours interval temperatures.

Daily hospital visits were acquired from the Clinical Department of the Research Institute of Maternal and Child Health, for the same period. Counts were taken with presence of disease exacerbation, when diagnosis included asthma of different level of disease severity for children (4–14 years) and teenagers (15–17 years) as based on the appropriate code according to the International Classification of Disease, version 9 or 10. Total count of visits over this time period was 310 cases, with 153 cases in 2013 and 157 – in 2014. These daily data were averaged for each month of two years separately and an Index of Seasonality (IS) for visits was derived as:

$$IS = (M_i / M_m) 100$$

where M_i is mean number of visits for a given month and M_m is mean number of visits for a month at the current year [4].

Day-to-day changes of mean daily temperatures dT_{mean} were calculated; frequency of days in each month with mean temperature changes more than 95th percentile (F_{mean}) was evaluated. To estimate if asthma visits depend on weather changes, coefficient of correlation (r) between both dT_{mean} and F_{mean}, and IS was examined.

Results and Discussion

Mean daily air temperature for the study period was 2.7°C with both extremes in 2014: minimum value −27.8°C on December, 26, and maximum +27.3°C on June, 3. Day-to-day changes in mean temperature averaged for two years show mean value of 2.1°C with two peaks in transition season: in March and May, and September – October. Additional search for cases with abrupt day-to-day changes (more than 95th percentile for 2-year record) shows the frequency of such days is higher in 2014 with peaks in transition period (April-May, October) and in December (Figure 1). 2013-year changes are less dangerous with maximum frequency (10%) in both March and October. As a whole the weather is more stable in summer without cases of sharp temperature change.

Using the IS metric defined in equation above, monthly BA visits distribution for the study period is shown in Figure 2. The results demonstrate IS for BA visits to be the highest in November-December (262 and 177%, respectively) of 2013, and in spring from March till May, 2014, with more heavily results for April (201%).

To examine possible response of human morbidity on weather, relationship between temperature changes and BA visits was studied. Coefficients of correlation r for mean monthly dT_{mean} and IS are 0.47 and 0.49 in 2013 and 2014, respectively. The results are more interesting when looking at frequency of days with sharp changes of temperature F_{mean}: $r = 0.69$ in 2013, and 0.43 in 2014.

The findings indicate strong enough dependence of BA in children from weather and its changes. The weather in Khabarovsk is characterized by very hot summers and extremely cold winters coupled by the abrupt weather changes that take place in the transitional seasons. The results manifest the high risk of BA exacerbation during both spring and autumn. However, secondary jump in winter (December, 2013) shows low temperature (extremely low in December,

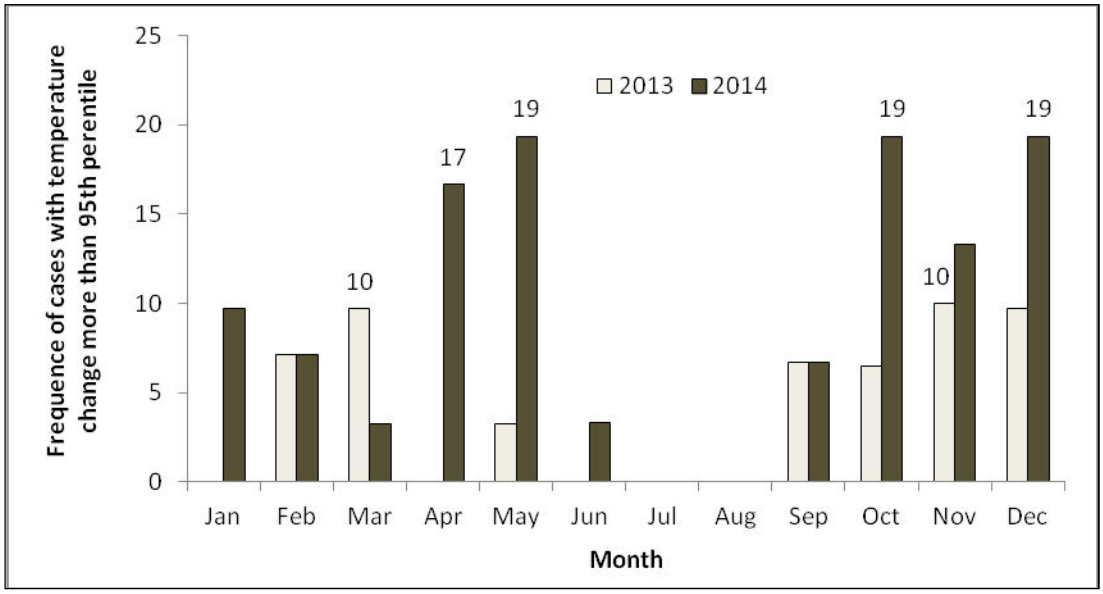

Figure 1. Frequency of cases with day-to-day change in mean temperature more than 95th percentile in Khabarovsk, 2013–2014

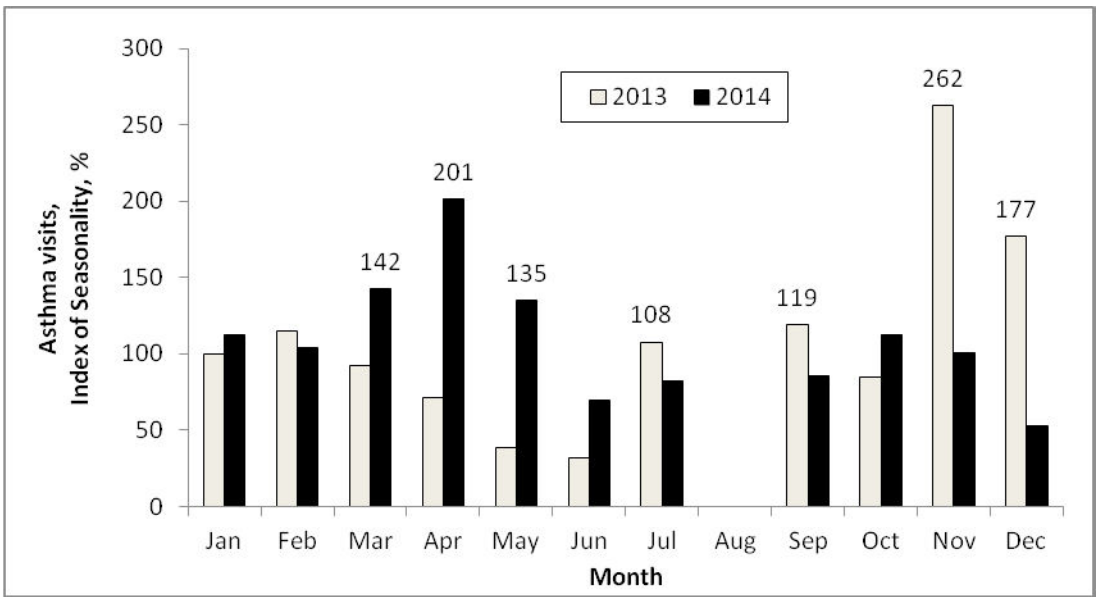

Figure 2. Index of Seasonality for child BA visits, Khabarovsk, 2013–2014

2014) can aggravate seasonal illnesses, primarily respiratory viral infections, causing additional load on children with BA. Earlier Driessen et al. [6] discussed decrease in lung function in cooling airway for asthmatic children. Relatively large and rapid changes in air temperature and air pressure, typical of the transitional seasons, lead to changes in the oxygen content of air that collectively are associated with pulmonary and cardiac insufficiency and bronchopulmonary disease [11].

The Russian Far East, especially its southern part, is an area of monsoon climate with heavy rains and extremely high humidity in warm season, particularly in period from July till mid-September [10], creating damp and moldy situations both inside and outside. It is documented, that tropically wet sultry weather with hot and humid air induces additional BA exacerbation [5].

It is well-known that thermal losses from the human body from respiration in winter are 1.5 times higher than in the transition seasons, and twice higher than in summer. This contrast may be a reason for increased respiratory morbidity during autumn and spring. Generally, the most severe thermal strain occurs with the adjustment shift from hot-to-cold during autumn [4]. Most certainly, this is one more reason for BA admission jumps in spring and autumn with peaks in November and April, that is shown in details in [3].

At the same time, dramatic peak in asthma visits in November, 2013, was definitely caused by consequences of catastrophic flooding on the Amur River in August-September, 2013, when conditions were created for uncontrolled spreading of fungal allergens in the air of damp and poorly ventilated buildings. The main source of mold spores can be spoiled food, organic waste, and air conditioning system. An earlier manifestation of BA with severe runs and frequent exacerbations increases the severity and duration of asthmatic attacks in ecologically dangerous areas [15]. It can be assumed the same reason, coupled with a sharp seasonal rise of temperature, provoked the maximum of BA visits in April, 2014.

It can be additionally marked that warm season is the period of flowering of allergen plants, with exacerbation of various allergic diseases and respiratory infections of the viral type [1, 16], triggering extra cases of BA visits and admissions.

However, natural and climatic environment is complicated by industrial emissions, rising concerns about the influence of ambient air pollution on respiratory illness [2, 12, 14]. In Khabarovsk, living near enterprises of heavy, chemical and engineering industry significantly increases the risk of BA disease. Chaotic planning structure in urban area, with thermal power plants, small boiler plants, highways and other industrial facilities within the residential zone, is typical for many settlements at the FE, aggravating the problem of industrial air pollution.

The important note should be done for a lack of data from Clinical Department in August. The main reason is a vacation period for both medical staff and families with a sick child – their physical absence in the city. A lot of families use holidays for recreation with the purpose of recovery in spa-centers in places with better weather conditions.

Conclusion

The research shows that BA visits are influenced by natural environment: abrupt changes in air temperature cause asthma exacerbation. Other factors, such as after-flooding mold and plant allergens aggravate the problem. Additional research is planned to find how day-to-day changes are connected with level of BA disease severity, to find the shape of this relationship (i.e. linear or non-linear) and whether temperature effect is lagged, using database of asthma admissions for period from 2010 till 2017. Bronchial asthma in children has a high medical and social significance; an adequate assessment of the environment (both social and natural) is necessary to reduce risk of BA morbidity and mortality, which will help to develop programs of preventive medical and social assistance, improving the overall quality of life, guaranteeing social well-being and economic development at the Russian Far East.

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ELDERLY MORTALITY AND CLIMATE AT THE RUSSIAN FAR EAST

Elena A. Grigorieva, Anna B. Sukhoveeva*
Institute for Complex Analysis of Regional Problems, FEB RAS, Birobidzhan, Russia
Email: eagrigor@yandex.ru, anna-sukhoveeva@yandex.ru (*corresponding author)

Medical and demographic statistics for elderly population is analysed for the regions at the Russian Far East, namely Primorsky and Khabarovsky Krai, Amur Region and the Jewish Autonomous Region (JAR), showing rapid growth of people at age cohort 65 years and older with double excess of women over men. On the contrary, "gender mortality dimorphism" at elderly ages is registered meaning all-cause mortality is 1.5-2.5 times higher for men than for women. More than 70% of all human losses for elderly population are caused by diseases of the circulatory system and neoplasms. Wet Kata Cooling Power by Hill, Net Effective Temperature and Wind Chill are bioclimatis indices chosen to illustrate the impact of climate on elderly mortality. The results show strong dependence of cardiovascular mortality on climate. Even keeping in mind that man-made social and economic environment plays great role in morbidity and mortality of elderly population, medical society must remember that critical exacerbation of chronic diseases can be triggered by discomfortable weather conditions. The results obtained can be used by health professionals in the development of strategies to mitigate the effect of weather in a changing climate, to promote, preserve and maintain public health.

***Keywords**: elderly population, mortality, climatic discomfort, Russian Far East.*

Introduction

Modern medicine faces challenges of global scale in providing assistance to a person at the vital stage near the limit of biological age. Population ageing accelerates morbidity rate, lead to an increase in morbidity and mortality worldwide. Older people diseases are aggravated by age-related changes in various organs and systems; elderly morbidity is characterized by a growing number of patients with chronic diseases of endogenous character (cardiovascular system and cancer). As a result of the population ageing and stable growth in morbidity during the last decades, elderly mortality increase occurs in Russia and its regions [2].

Social development is the priority issue for the eastern regions of Russia, especially those close to the state border [23]. In general it has obvious social, economic and geopolitical consequences for the future of the Russian Far East (FE). The problem creates potential threat to national security not only on the regional scale, but also throughout the country [20]. Statistics show that the rate of population aging is 2.6 times higher at the FE than the national average, raising significant social, economic, medical and social challenges [16].

It is well known, that FE is a climatically extreme region with a massive gradient of thermal comfort; weather and climate here affects human health and well-being, causing additional increase in morbidity and mortality [7, 9, 10]. Elderly people with cardiovascular and respiratory disease are sensitive to weather and its changes, and are considered the most climate vulnerable part of the population [3-5, 7, 17, 18, 25]. The aim of the current work is medical and demographic analysis of the elderly population, and the study of the relationship between elderly all-cause and cause-specific mortality and thermal (dis)comfort in the south of the FE.

Data and Methods

Russian FE is located at the territory with diverse topography, including plains and mountains, in the temperate monsoon climatic zone. It is characterized by an extreme continental regime of annual temperatures, noted for its excessive variability. The area is influenced by the great Asian continent, on the one hand, and the vast water basin of the Pacific Ocean, on the other. Conditions in winter are similar to those in Siberia with cold temperatures and high wind. In summer, the climate is like that of the warm, humid tropics with high air temperatures and high relative humidity [11, 12].

The study area is a continental part at the south of the Russian FE, and includes Primorsky and Khabarovsky Krai, Amur Region and the Jewish Autonomous Region (JAR). Standard climatic data used are monthly air temperature, relative air humidity and wind speed from the Handbook of Climate. Demographic data used are for period 2000-2015 [24]; mortality all-cause and cause specific data separately for two gender groups with special interest on elderly people of age cohorts 65 years and older (age cohorts 65–70 (D65), 70–75 (D70), 75–80 (D75), 80–85

(D80), 85 and older (D85)), are taken for period from 2011 to 2017 [19]. Non-accidental mortality is classified according to the International Classification of Diseases and Related Health Problems, 10th revision (ICD-10 codes A00-R99; World Health Organization 2007): ICD codes I00-I99 for cardiovascular mortality.

Human thermal stress and climatic discomfort it causes is analyzed; combination of bioclimatic thermal indices is calculated using climatic data. Thermal indices most suitable for a particular application are chosen according to the results of the previous special research project [6, 8]. Particularly, indices accepted for thermal (dis)comfort estimation in current work are: Net Effective Temperature [1], NET (°C); Wet Kata Cooling Power by Hill [14], H (W m^{-2}); and Wind Chill by Siple and Passel [21], WC (kcal m^{-2} hr^{-1}) – those highly explored in the former Soviet Union and in Russia. The output for NET is equivalent temperature, for H and WC – calorific unit [1, 8, 14, 21]. The previous research has shown that indices chosen are the most appropriate in the assessment of the climatic thermal impact on human well-being and comfort [9, 10, 12, 13]. There are three main advantages to using them: a) they are based on the main environmental parameters: air temperature, humidity and wind speed; b) simplicity of calculation and ease for interpretation by both specialists and laypersons; c) possibility of application all year round [6, 8, 13]. Methods for calculation of a particular index and its characteristics are available elsewhere [1, 10, 13, 14, 21, etc.].

Bioclimatic indices are estimated for each month and averaged for summer (months from June till August), winter (months from December till February) and for the whole year. Pearson's correlation is used to assess the linear relationship between thermal indices and elderly mortality. The following points are the accepted guidelines for interpreting the correlation coefficient (r): $r < 0.3$ – weak, 0.3 to 0.7 – moderate, $r > 0.7$ – strong positive relationship; negative values indicates an inversely proportional relationship.

Results and Discussion

Retrospective assessment of population dynamics in period from 2000 to 2015 demonstrates that change in its age and gender structure repeats the national trends with reduce of working-age population and the rapid growth of other cohorts, especially older ones. Proportion of elderly people in 2015 was 12.0 % in Khabarovsky Krai, the Amur Region and Primorsky Krai, and 11.1% in the JAR. According to the UN standards, the population of these regions has remained "old", and trends towards dramatic ageing coupled with a steady decline in total population. During study period population of 65 years and older increased by 5.9% in Primorsky Krai (with total 259.3 thousand people in 2015), by 3.1% in Khabarovsky Krai (161.5 thousand people), by 2.7% in the Amur Region (90 thousand people), and by 6% in the JAR (18.8 thousand people). Another issue of concern is a double excess in the number of elderly women over men, which demonstrates a significant gender disproportion.

At the same time, analysis of elderly mortality shows that gender disparity is stratified reversely with excess of male mortality over the female mortality. In 2000-2015 the indicator of "gender mortality dimorphism" for age cohort 65-69 years was 2.4-2.7 in Khabarovsky Krai, 2.2-2.5 in the JAR, 2.2-2.7 in the Amur Region, 1.8-2.3 in Primorsky Krai. For the age cohort 70 years and older, the excess was 1.4-1.5 in Khabarovsky and Primorsky Krai and in the Amur region; 1.4-1.8 in the JAR.

During the last years the structure of mortality causes for elderly population has not changed significantly both in the study area and in Russia as a whole. The leading causes of death in cohorts 65-69, and 70 years and older are diseases of the circulatory system and neoplasms, giving almost 75-85% of all human loss. In the JAR in 2015 diseases of the circulatory system was at the first place contributing 59% to the total mortality, 50.6% of which were coronary heart disease and 26.6% – cerebrovascular diseases [22].

Bioclimatic comfort indices are calculated separately for both warm and cold seasons. Winter thermal conditions refer the entire study area to the zone with "extremely cold" conditions and an extremely high probability of freezing. Low temperatures are aggravated by strong winds and high humidity. As a result, the perceived temperatures expressed by NET (°C) are lower than the actual ones by up to 20–30°C, reaching −50…−55°C. For example, extreme weather caused by strong winds is observed in river valleys (e.g. Amur River) or on the coast of the Pacific Ocean. At the same time, intermountain basins are described by less severity, despite lower actual temperatures. In summer almost all study area is characterised by comfort conditions with cool thermal discomfort further north. Overall, the negative NET value is lower if winter is more severe; vice versa, in summer positive NET is higher further to south where climate is warmer with maximum probability of heat waves. In winter both H and WC increase in regions where climate conditions are characterised by stronger discomfort.

Linear correlation coefficients (r) were calculated to determine the relationship between bioclimate indices averaged for winter, summer and the whole year, and all-cause and cardiovascular mortality for two gender groups. All-cause elderly mortality showed moderate positive correlation for yearly NET (0.66) and for winter H (0.66). The most significant depen-

dence on weather is found for cardiovascular disease. As an example, the highest results of correlation coefficients for bioclimatic indices and cardiovascular mortality separately for two gender groups and age cohorts 65–70 (D65), 70–75 (D70), 75–80 (D75), 80–85 (D80), 85 and older (D85), are summarized in Table.

Summary in Table demonstrates that cardiovascular mortality is recorded better by both yearly Hill index and winter Wind Chill, for both men and women and all selected age groups. In almost all cases male mortality has higher correlation coefficients than female mortality. Results in Table are almost similar for all age groups. The values with lower coefficients not shown in Table, present moderate correlation for cohorts from 65-70 till 75-80 indicating these age groups are sensitive to weather, especially those with cardiovascular disease. However, correlation is weak for elder groups 75-80, 85 and older; they die mostly of old age and depend more on quality of life.

Previous studies have shown that NET is the better indicator of the relationship between climate and morbidity [9, 10]. Current analysis reveals elderly mortality can be determined by any index, with particular interest to Hill for cardiovascular male and female mortality.

Generally speaking, elderly population is more vulnerable to climate effects than younger age groups, as heat transfer mechanisms in older people are not sufficiently stable. Literature review shows that physiologically aged blood vessels are influences by weather more effectively [2–5, 15, 17, 18, etc.]. Moreover, comprehensive assessment of climate and weather impact on human life should consider not only its thermal load, but sudden changes of air temperature, air pressure and wind speed [7]. Changeable weather with day-to-day fluctuations, especially in winter and in transitional seasons, adversely affects people with heart failure and bronchopulmonary diseases.

Nevertheless, it must be borne in mind that man-made social and economic environment plays a great role in morbidity and mortality of the whole population, as well as of its elderly cohort. Center for control and prevention of diseases of the United States notes that the risk of additional deaths related to the weather (including heat waves, cold, floods and storms), can be 2-7 times higher in areas with low income compared to areas with high income [4]. At the same time, climate and weather amplify negative economic situation. In most cases, an increase in mortality can be recorded, when specific cause of death is not hypothermia or heat stroke, but other pathological conditions, for example, aggravation of chronic illnesses. This identification of death causes is mainly associated with a critical exacerbation of chronic diseases triggered by discomfortable weather conditions.

Conclusion

Current research illustrates rapid growth in elderly age population at the south of the Russian Far East in last decades with a double excess of elderly women over men. Conversely, the all-cause elderly mortality is higher for men than for women: in study ares “gender mortality dimorphism” is more than 1.5-2.5 for age cohort 65 years and older. The structure in death causes of elderly population indicates that diseases of the circulatory system and neoplasms are the leading causes of elderly mortality, giving more than 70% of all human losses in old age. Bioclimatic indices selected for the characteristics of climatic discomfort show good results in estimation of their effect on mortality of people 65 years and older, and can be used for detailed studies at the meso-and micro levels. Future research on daily mortality and weather data will help to identify the primary drivers of weather-related health impacts, with the main ultimate goal to develop targeted interventions to mitigate the effects of weather in a changing climate.

Table

Results of correlation analysis between bioclimate indices averaged for summer and year, and cardiovascular elderly mortality, Russian Far East

Bioclimate Index	NET* (year)		H (year)		WC (summer)	
Age cohort/Gender	male	female	male	female	male	female
D65	−0,85	−0,77	0,96	0,95	0,98	0,95
D70	−0,83	−0,76	0,95	0,99	0,98	0,95
D75	−0,78	−0,68	0,96	0,93	0,95	0,90
D80	−0,84	−0,65	0,97	0,94	0,98	0,88
D85	−0,76	−0,60	0,98	0,95	0,95	0,85

*Net Effective Temperature, NET [1]; Wet Kata Cooling Power by Hill, H [14]; and Wind Chill, WC by Siple and Passel [21]

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HUMAN PARASITES IN THE AMUR RIVER: THE RESULTS OF 2017–2018 FIELD STUDIES

Yulia V. Tatonova[1]*, Daria A. Solodovnik[1], Hung Manh Nguyen[2]

[1]Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch, Russian Academy of Sciences, Vladivostok, Russia
[2]Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, Hanoi, Viet Nam
Email: ytatonova@gmail.com (*corresponding author)

Foodborne diseases are an important health problem worldwide. In the Far East of Russia, the greatest epidemiological significance is found for representatives of four trematode genera, including Clonorchis and Metagonimus. In 2017, it was discovered that a new species of Metagonimus suifunensis, previously described as M. yokogawai, was distributed in the Primorsky Krai and the Khabarovsky Krai. In 2017-2018 the infection of the first and second intermediate hosts by Clonorchis sinensis u Metagonimus spp. was assessed in the Amur River basin. New results for these parasites from the Khabarovsky Krai, comparison with data for the Primorsky Krai and discussion in connection with the human activity in the Far East region are reported in current research. A possible location with the presence of a disruptive selection for Metagonimus spp. was found in Khabarovsky Krai. In addition to Clonorchis sinensis and Metagonimus spp., new information on the distribution was obtained for another trematode species in Khabarovsky Krai.

Keywords: *Clonorchis sinensis, Metagonimus spp., human parasites, Russian Far East.*

Introduction

Foodborne diseases is an important health problem worldwide. In the Russian Far East (FE), the greatest epidemiological significance is found for representatives of four trematode genera, including *Clonorchis* (Opisthorchiidae) and *Metagonimus* (Heterophyidae). *Clonorchis sinensis* parasitizes in the human liver causing proliferative processes in the bile duct tissue and leading to pathological changes in the organ. This parasite can cause cancer and is officially included in the list of biological carcinogens [2]. Representatives of *Metagonimus* are intestine parasites of humans and animals. High invasion intensity can also lead to a severe course of the disease. In 2017, it was discovered that a new species, *Metagonimus suifunensis*, previously described as *M. yokogawai*, was distributed in the Primorsky Krai [4] and the Khabarovsk Krai (unpublished data). In 2017-2018, within the framework of the field studies supported by the Russian Science Foundation (project RSF No. 17-65-00004), the infection of the first and second intermediate hosts by *Clonorchis sinensis* и *Metagonimus* spp. was assessed in the Amur River basin.

First intermediate hosts of *C. sinensis* in the southern part of the FE are snails from the Bithynidae family (genus *Parafossarulus*), while snails of the Semisulcospiridae family are the hosts of *Metagonimus* and many other trematode species. It is important to note that there are some problems with taxonomic identification of the hosts mentioned above. For example, Strong and Köhler [5] indicated that a description of genus "*Parajuga*" (Semisulcospiridae) does not distinguish any anatomical features of this group of mollusks, and on the basis of the genetic data obtained in their study they indicated that this genus is not considered valid. In another work based on genetic data, Köhler [3] reduces one of the representatives of the genus "*Parajuga*" to *Koreoleptoxis amurensis*. According to our own preliminary molecular data, the taxonomy of these host species requires additional studies. Moreover, the presence of a large number of species in the genus previously known as *Juga* ("*Parajuga*") is in doubt. Therefore, it is designated conditionally that the snails, from which the cercariae of parasites were obtained, belong to two genera, *Parafossarulus* for *C. sinensis* and *Koreoleptoxis* for *Metagonimus* spp. Second intermediate hosts of *Clonorchis sinensis* и *Metagonimus* spp. are Cyprinidae fish. In current research data for the Khabarovsky Krai are described.

Materials and Methods

The first and second intermediate hosts of parasites were collected from 13 localities of the

Khabarovsky Krai. Only emitted cercariae were analyzed. The snails were not crushed to search for sporocysts and rediae of parasites. The naturally infected Cyprinidae fish were fed to rats and (or) ducklings. Euthanasia of laboratory animals was carried out in accordance with the Committee on the Ethics of Animal Experiments of the Federal Scientific Center of the East Asia Terrestrial Biodiversity, Russia (Permit Number 3 of 2 June 2011). Since the difficulties in identifying *Metagonimus* representatives based on morphological data [4, 6], have been noted previously, cercariae, metacercariae and adult flukes of parasites were collected for subsequent identification at the molecular level.

Results and Discussion

Yagodnoe village (the Amur River). 243 specimens of *Koreoleptoxis* snails were collected, from which four were infected. Cercariae of *Metagonimus* spp. and *Nanophyetus salmincola* (Nanophyetidae) were detected. Fish were not examined.

The Machtovaya River. 17 of 73 collected *Koreoleptoxis* snails were infected by cercariae from different genera: *Pygidiopsis* (Heterophyidae), *Plagioporus* (Opecoelidae), *Sanguinicola* (Sanguinicolidae), *Echinochasmus* (Echinostomatidae), as well as stilet cercariae of various genera. 28 fish were examined and metacercariae were not obtained.

Komsomolsk-on-Amur city (the Amur River). 341 samples of *Koreoleptoxis* snails were examined. Nine infected snails were obtained, from which eight emitted *Metagonimus* cercariae, another one had *Echinochasmus milvi* cercariae. Fish were not examined.

Komsomolsk-on-Amur city (Mylki Lake). The snails were not collected. Infected by opisthorchiid metacercariae fish were fed to rats and duckling. No trematodes were detected in the rats, while adult *Metorchis* flukes were obtained in the gallbladder of duckling. Intestine of the duckling had adult flukes from the Cyathocotylidae family.

The Gur River. 218 specimens of *Koreoleptoxis* snails were examined, from which 55 emitted cercariae of different genera: *Metagonimus*, *Pygidiopsis*, *Echinochasmus*, *Nanophyetus*, *Centrocestus* (Heterophyidae), stilet cercariae of various genera. The most of infected snails (30 specimens) had *E. milvi*. One snail had indeterminate furkocercariae. The naturally infected fish were fed to rats and ducklings. No rats were infected. Two ducklings had adult *Metagonimus* flukes in the intestine.

The Anuj River. 40 of 301 examined *Koreoleptoxis* snails were infected by trematodes from *Metagonimus*, *Pygidiopsis, Microparyphyim* (Echinostomatidae) and *Nanophyetus* genera. 17 of 40 snails had stilet cercariae of tree different types. One snail emitted both *Pygidiopsis* and stilet cercariae. Infected *Phoxinus percnurus* were caught in lake near to the Anuj River. Opisthorchiids metacercariae were detected in 100% fish, which were fed to rats and one duckling. One specimen of adult *Metagonimus suifunensis* (confirmed by genetic data) was obtained in the intestine of one rat. In the duckling, the liver and two blind pouches of intestine contained a large number of adult *Opisthorchis* flukes. Both blind pouches were 5 times larger than usual size. The species of this parasite has not been determined, because whole parasites could not be extracted. They had a long body that was located in the tissues of the host's organs in several projections at once, while the parasite density did not allow separating individuals. However, anterior parts of parasites were collected for genetic analysis.

Gassi Lake. 145 specimens of *Koreoleptoxis* snails were examined, from which 14 were infected by *Metagonimus* spp. and *E. milvi*. The rats were fed by naturally infected fish. Four adult *C. sinensis* were detected in the liver of one rat.

Sindinskoe Lake. 157 specimens of *Parafossarulus* snails were examined. *Metorchis* sp. cercariae were detected in 18 of them. Infected fish were fed to two rats. On day 28 after infection, they were contained adult *C. sinensis* in their livers.

Petropavlovskoe Lake. The snails were not collected. Infected fish were fed to one rat. No trematodes were obtained in its liver and intestine.

The Kiya River. 63 specimens of *Koreoleptoxis* snails were examined, from which only one was infected by *E. milvi* cercariae. Fish were not examined.

The Bikin River. 348 specimens of *Koreoleptoxis* snails were examined, from which 14 were infected by *Metagonimus* spp., *Pygidiopsis* sp., *Centrocestus* sp. and *E. milvi* cercariae. Metgonimus was found in half of infected snails. Four snails had stilet cercariae. *Rhodeus sericius* (all specimens were infected) were fed to rats and ducklings. One rat contained eight *C. sinensis* in its liver. In the intestines of two ducklings, we obtained adult *Metagonimus* flukes and adult trematodes from the Cyathocotylidae family. In the gallbladders of two another ducklings, adult *Metorchis* were obtained.

The Amur Channel. In two rivers flowing into the Amur channel (Bychikha and Polovinka), fish were caught and checked for the presence of metacercariae. No metacaraciae were found. 326 specimens of *Koreoleptoxis* snails were examined. Three of them were infected by cercariae of *E. milvi, Centrocestus* sp. and stilet trematoda.

The Chirka River and two rivers flowing to it (Odyr and Tsypa). *Phoxinus percnurus* were caught in the Odyr and Tsypa Rivers, all of them were infected

by metacercariae by *Metagonimus* spp. Intensity of infection was higher in the Odyr River. Fish from both localities were fed to rats and ducklings. Ducklings were not infected, while 355 and 43 adult *Metagonimus* were found in the intestines of rats from the Odyr and Tsypa Rivers, respectively. 230 specimens of *Koreoleptoxis* snails were examined, from which one, five and four samples were infected by *Plagioporus* sp., *Metagonimus* spp., and *E. milvi* cercariae, respectively, and 29 snails emitted stilet cercariae of various genera.

Thereby, *Koreoleptoxis* snails emitted cercariae of *Metagonimus* spp. in seven of 10 investigated localities, where snails have been collected in this field trip. For two other localities, the number of collected snails was small, and it can be reason that these species were not obtained. At the same time, the absence of *Metagonimus* spp. in the Amur Channel, despite a large number of investigated mollusks. This part of the Amur Channel is located near the Ussuri river, and we plan to explore this area more thoroughly, since the absence *Metagonimus* spp. in the first intermediate and second intermediate hosts can lead to a disruptive selection of parasites from this genus. It seems likely, since we have revealed some differences in haplotypes of *Metagonimus suifunensis* from Primorsky Krai and the Khabarovsky Krai (data were not published). Currently, it is not obvious what species of *Metagonimus* were circulated in the Khabarovsky Krai, the issue would be clarified after obtaining molecular data later in the process of project. Nevertheless, the presence of *Metagonimus suifunensis* has already been confirmed for one locality (the Anuj River).

It is interesting that the list of obtained genera of parasites coincides with earlier described species for *Juga* snails from the Primorsky Krai [1]. However, not all species were detected in the Khabarovsky Krai due to the smaller size of samples: we examined only 2288 *Koreoleptoxis* snails, while Dr. Besprozvannykh examined 14 255 snails for infection by trematodes [1]. Despite the relatively small size of the sample in the Gur River, the high level of infection prevalence (25%) in the snails was revealed. The most of snails were infected by *E. milvi*, which infected kitten in the experiment of Besprozvannykh [1]. That is, it can be potential parasite of humans. The Gur River has very clean water, and many fishermen and their families are fishing here, as in other rivers, wherever the infected snails were collected. It should be noted that of the *Echinochasmus* genus is identified only *E. milvi*, while *E. suifunensis* are also distributed in the Primorsky Krai. At the same time, cercariae of *Nanophyetus* were obtained in only three localities with low prevalence. It was surprised, because representatives of this genus included in the list of trematodes with highest epidemiological significance in the Russian Far East. No *Paragonimus* cercariae (the fourth of the most dangerous species of trematodes in this region) were detected in the investigated *Koreoleptoxis* snails.

The study of the first intermediate host of *C. sinensis* was more difficult. Bithyniidae snails have not been discovered in all water bodies despite the presence of various representatives of the Opisthorchiidae family. In addition, it is interesting to find the new *Opisthorchis* species, and the plans are to continue the study in the near future.

Conclusion

The data obtained can serve as the beginning of a comprehensive study, including confirmation of the taxonomic status of parasites and their hosts based on molecular data and the study of phylogeography and historical processes in populations both parasites and their hosts.

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CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE

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GLOBAL WARMING, CLIMATE CHANGE AND ITS THREATS TO SUSTAINABLE AGRICULTURE

M. Qasim Jan[1]*, Khazima Muazim[2] and Arshad Ashraf[3]
[1]University of Peshawar, Peshawar, & Pak Academy of Sciences, Islamabad, Pakistan
[2]OIC Standing Committee on S&T Coop (COMSTECH), Islamabad, Pakistan
[3]National Agricultural Research Centre (NARC), Islamabad, Pakistan
Email: mqjan@yahoo.com (*corresponding author)

Global warming, climate change and environmental degradation constitute the biggest threat to human civilization. Temperature measurement records on land and sea, shrinking polar ice sheets, recession in mountain glaciers, rise in sea level and ocean acidification are manifestation of global temperature increase, estimated at 0.8–1.0°C since 1880. The present day global warming is generally considered a consequence of the accumulation in atmosphere of greenhouse gases, notably CO_2, which result from burning of hydrocarbons in industry, power generation, vehicles and domestic use. Global warming would result in melting of glaciers and polar icecaps, unpredictable weather patterns, natural disasters (e.g., floods), disruption of existing communication systems and infrastructure, health issues, sea level rise and unmanageable threat to coastal regions. It can trigger the vicious circle of food insecurity, human migration and conflicts. Climate change can cause unpredictable changes in weather patterns, erosion of soil, desertification of cultivable land, disruption of existing irrigation systems, and reduction of tropical forest cover. Hence, it would have severe impact on agriculture sector, food security and its supply chain. Melting of the glaciers in Tibet and greater Himalaya would adversely affect the food security and life pattern of three billion people. To mitigate climate change and harness food security, diverse sustainable and environment friendly techniques, such as crop rotation, integrated pest management, hydroponics, cultivation of salt tolerant plants, and efficient irrigation techniques need to be employed. But, most importantly, the impending disaster of global warming can only be avoided by urgently controlling the emission of greenhouse gases.

***Keywords**: Global warming, climate change, sustainable agriculture.*

Introduction

Climate change is an enormous threat to humanity and sustainable development. It is conceived to be characterized by extreme and unpredictable weather conditions, changes in precipitation pattern and overall environmental degradation. Hence, climate change and its causes have become the focus of research and heated debate. Although natural causes (e.g., solar flare ups, volcanism, floods, storms, meteorite falls) have been responsible for climate changes in the geological past. There is a general agreement that the present day global warming is rooted in anthropogenic activities. Here we describe briefly the causes and consequences of global warming and climate change, and their threat to agriculture and food security.

Evidence, consequences and mitigation of climate change

Increase in temperature over ocean's surface, on continents (weather stations data), near surface (troposphere 50 years satellite temperature) data), and in the heat content of the oceans, rise in sea-level, recession in glaciers and reduction in polar icecaps are striking evidences of global warming [1, 2]. Recorded data suggest that global temperature has risen by 0.8–1.0°C over the past 130 years, an alarming rate indeed (Figure, Left). Human activities empirically known to influence climate and ecosystem include burning of fossil fuels in industry, automobiles, power plants, and buildings, waste disposal, deforestation, urbanization, agriculture, and wastage of water. The consumption of fossil fuels results in the production and

accumulation of Green House Gases (GHGs), such as CO_2, CH_4, N_2O, and fluorinated gases, which take various lengths of time for removal from the atmosphere. CO_2, the principal GHG, takes flabbergasting one hundred years for its removal, and has increased significantly over the past century to 400 ppm (ca. 40 B tons).

The consequences of the climate change can be disastrous, long lasting, and even irreversible. Changes in patterns of rainfall and snow, increased likelihood of drought and severe storms, decline in ice cover, melting of glaciers, increase in floods (including GLOFs), landslides, rise in sea level, higher humidity, changes in animal and plant behavior, faunal extinction, bleaching of coral reefs and dying of the African iconic baobab trees are the feared scenarios. Climate change would impact infrastructure, steady supply of energy, patterns of livelihood, and standard of living, leading to a vicious socioeconomic burden. At the present rate of global warming, around 75% of world's population will be exposed to deadly climate conditions by 2100. Water borne and water related diseases, such as malaria, dengue, diarrhea, dysentery and typhoid, are likely to become epidemic. Global warming is projected to cause approximately 20,000 heat-related deaths among the elderly in 2030. There would be severe impact on agriculture sector, food security, food, supply chain, and fresh water, which will initiate human migration and social conflicts.

Global response to climate change started as early as 1992 under an international treaty aka Framework Convention on Climate Change (UNFCCC). This has led to significant progress and the Paris Agreement 2016 was adopted as an implementation plan to combat climate change. This policy demands global commitment to keep the temperature increase below 2°C, preferably not more than 1.5°C by the end of this century. More than 180 countries have pledged to limit carbon emissions as part of Intended Nationally Defined Contributions (INDC) to keep temperature from rising. Use of renewable, environment friendly energy sources are to be given priority while traditional energy sources dependent on fossil fuel are to be replaced. These INDCs are not legally binding on any country, and no end timeline is set forth for the task. The Paris agreement also lays an added emphasis on the financing and budgeting of the losses; damages caused by climate change and for the infrastructure change that is required for curbing emissions. It looks difficult to achieve these targets; therefore, there is an urgent need for devising a more effective long term plan to control the temperature rise to the recommended limits by the end of this century.

Remedial steps on global scale and changes in lifestyle are touted as major ways of effectively fighting climate change. The remedial steps include use of clean energy, removal of CO_2 from atmosphere, increase in forest cover, replacement of coal by gas in power generation, and geo engineering. Changes in lifestyle, which would help reduce environmental degradation, include expanded use of renewable energy in buildings, reducing waste, avoiding unnecessary use of vehicles, eating less meat, and spatial planning and infrastructure to accommodate green and environment friendly infrastructures.

Climate change and agriculture sustainability

Agriculture is vital for human survival and is probably the most vulnerable human enterprise to

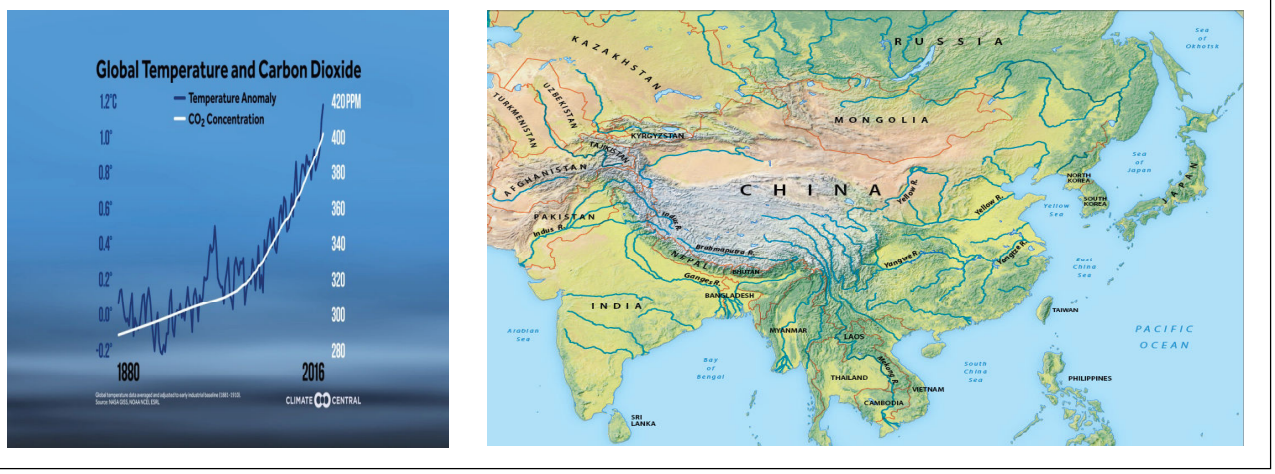

Figure Left: Degree of temperature increase and CO_2 accumulation in the atmosphere from 1880 to 2016 (NASA GISS, NOAA, NCEI, ESRL). Right: Himalaya-Karakorum-Tibet glacier-fed major rivers

changing climate which will impact agriculture in a complex and interconnected fashion. Water resources in particular will be the most affected natural ecosystem due to climate change and increasing need of ever-growing population. Continued global warming will cause melting of the polar ice caps and mountain glaciers, leading to sea level rise and increase in water-related disasters such as flash floods and cyclones. Global warming would be particularly disastrous for agriculture activities in the southeastern half of Asia that depends heavily on river waters drawn from the glaciers of Himalaya, Karakoram, Pamir, Hindu Kush, and snows of the Third Pole, i.e., Tibetan Plateau (Figure Right). This region, with the largest irrigation system and alluvial flood plains, provides nourishment, hydroelectricity, and transport facility to approximately two billion population. Melting of polar ice caps and glaciers, and heavy rains would also lead to GLOFs, flash floods, rapid erosion of soil cover, sediment-filling of water reservoirs, disruption of waterways and irrigation systems, and coastal areas inundation. The rise in sea level (hence greater surface area) and rising temperatures would likely result in greater evaporation and higher global humidity, but its overall impact on green gas house effect and quantity of rainfall are not clear.

Climate change would cause changes in agro-ecological conditions which, in turn, would impact crop yield, nutrition value and livestock productivity. Crop cultivation and harvesting, support pests, weeds and plant pathogens, with excessive precipitation and accumulation of GHGs affecting soil's biogeochemical cycle. Growth of crop plants is driven by interaction among CO_2, temperature, light and precipitation. Overall seasonal precipitation determines the yield over large areas, but stress and dry spells threaten productivity, even a few hours at critical growth stages. Increase in temperature will consequentially affect growth, nutritional value and required yield of the crop plants. The rise in warming condition may also affect the bee population, and pollination stage of the plants, leading to hindrance in development of fruit, fiber and grain and, in return, negatively influencing the crop yield. Growth of green and leafy vegetables would be severely hindered by rise in temperature. Negative effects of high night temperature on grain development are confidently and abundantly reported. Livestock is also affected directly and by lack of pasture and forage availability, and compromised quality as the agriculture production is affected. Livestock exposed to higher night time temperature are likely to have reduced milk, meat and egg production due to increased physiological stress.

The quality of soil and water, two key factors that have significant impact on the agriculture production, get affected by climate change directly or indirectly. Soil erosion is caused by floods which affect the cultivability of the land while soil nature is affected by carbon content. Changing climate will not only impact the quantity but also the quality of water that is available and accessible for irrigation use.

Another way through which agriculture is affected by climate change includes weeds, insects and disease re-emergence. Major losses to crop production globally are caused by weeds (estimated at 34%), insects (18%) and diseases (16%). Increase in temperature helps induce higher incidences of plant and livestock pathogens, and geographical distribution/relocation of insects and diseases [3]. It is important to note that the weed species can adapt to higher temperatures and CO_2 levels than the crop plants, providing them a competitive advantage. This re-emergence will cause increased use of pesticides and insecticides for the protection of agriculture and livestock health, which can lead to pesticide resistance and entrance of these chemicals into food chain, creating long-term implication for food safety and consumption.

Rapid population growth, increasing urbanization and natural habitat degradation have rendered the thickly populated South Asia a highly vulnerable region to climate change, thereby posing a serious threat to agriculture and food security. Some of the major challenges of climate change for agriculture in this region include increasing temperatures, availability of irrigation water, increased variability of monsoon, severe water-stressed conditions in arid and semi-arid areas, and extreme events, such as floods, droughts, heat waves, cold waves, and cyclones.

Temperature increase will negatively impact crops which are grown close to their temperature tolerance threshold (wheat, rice and maize, vegetables) in tropical and temperate regions of South Asia although individual locations may benefit [4]. It is important to note that the risk of food security and climate impact on agriculture is greater in low altitude areas. Indirect impact on agriculture is likely to emerge from changing soil moisture content, erosion of soil, disruption of existing irrigation systems, frequent occurrence of pests and crop pathogens.

Adaptation and mitigation options for sustainable agriculture

It is necessary to accelerate the research for climate change adaptation and mitigation in a multi-dimensional approach. The adaptation initiatives need to focus on development of new cultivars, innovations in plant protection, advances in biological engineer-

ing, enhancing productivity of horticultural crops, broadening the genetic diversity, and development of resource conservation technologies. The following adaptation measures are needed for sustainable agriculture development and food security:

A) Crops related measures, including alteration in sowing dates, use of new crop varieties, advance seasonal weather forecast, changes in irrigation methods, development of short duration, drought and heat-tolerant varieties, changes in cropping pattern, e.g. replacing high water requiring crops with low water requiring ones, and inclusion of legumes in all-cereal cropping pattern.

B) Water related measures, involving adapting water smart technologies like drip, sprinkler and sub-surface irrigation systems, rainwater harvesting, solar pumping and integrating irrigation with water sensitive growth stages of crops.

C) Soil related measures, entailing soil mulching to suppress evaporation and lower soil temperature, laser land leveling and improving soil drainage to prevent soil degradation.

The long-term response to climate change may include investing in creating new or improving existing infrastructure, e.g. water storages (through aquifers or dams), water harvesting structures, canal lining. The impacts of extreme events can be avoided, for example, through restricting development in floodplains and areas of increasing aridity. Adoption of clean energy and increase in forest cover are some of the viable options for climate change mitigation.

Conclusion

Agriculture and food security would be drastically affected under unrestrained climate change. Adaptation measures, such as conservation of water, use of organic fertilizer, cultivation of drought and salt resistant crop varieties, integrated pest control, hydroponics and, of course, reducing GHG in the atmosphere would be needed to protect agriculture from the negative impacts of climate change. Additionally, it is highly imperative that actions are taken in the areas of consumption and production trends, mass education and research, which will help to better understand climate stresses, economic losses and alternative methods and approaches.

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CARBON SEQUESTRATION POTENTIALITY AND ITS ECONOMIC ANALYSIS OF DIFFERENT LAND USE SYSTEMS IN THE NORTHERN PART OF BANGLADESH

M. S. Bari[1]*; M.B Abubakar[2] and M.S. Rahman[1]
[1]Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh
[2]Kano University of Science and Technology, Kano, Nigeria
Email: barimdshafiqul@gmail.com (*corresponding author)

This study was conducted to evaluate the carbon sequestration potentiality of different land use systems in the Northern part of Bangladesh. Common land use systems like cropland, roadside, homestead and orchard were used. Data were recorded from both tree growth parameters (height and diameter at breast height) and under storied vegetation (herbs, shrubs and crops) in order to estimate the total land use biomass accumulation. Complete measure of 40 m line transects in cropland, 40×5 m quadrant in roadside, 40×40 m quadrant in both orchard and homestead were used. At every sampling point, under stories biomass sample were taken from 1×1 m quadrant. The results showed that there was significant difference of carbon sequestration potentiality of different land use systems. For the main effect of different land use systems on carbon sequestration, there was significantly difference in respect of tree height (m), dbh (cm), carbon sequestration per tree (t ha^{-1}) and total carbon sequestration by the land use systems (t ha^{-1}). The highest total carbon sequestration (325.33 t ha^{-1}) was recorded from double roadside land use system and the lowest (36.51 t ha^{-1}) was obtained from cropland land use system. However, in case of economic of carbon sequestration, among the six land use systems double roadside gave maximum (4879.95$ t ha^{-1}) monitory returned. So, double roadside tree plantation is a better land use option for reducing atmospheric carbon. Therefore, more emphasis should be given in roadside plantation for mitigating the green house effects.

Keywords: *carbon sequestration, land use, road side plantation, Bangladesh.*

Introduction

Tropical forests play an important role in the global carbon cycle [16]. They contain about 40% of global terrestrial carbon, account for more than half of global gross primary productivity, and sequester large amounts of carbon dioxide (CO_2) from the atmosphere [3, 7, 18]. Carbon is stored in forests predominantly in live biomass and in soils, with smaller amounts in coarse woody debris [15]. In tropical forests worldwide, about 50% of the total carbon is stored in aboveground biomass and 50% is stored in the top 1 m of the soil [6].

The problem of global climate change is considered to be one of the most important to the environment; it has been at the center of scientific debate in recent years. Carbon dioxide (CO_2) emissions from land use and land use changes, predominantly from forested areas, account for 33% of global CO_2 emissions between 1850 and 1998 [4]. Increasing demand for food, fodder, fuel and round wood is rising the pressure on land-use systems, and conservation and sustainable development of land-use systems are critical for meeting those demands sustainably and stabilizing CO_2 concentration in the atmosphere to mitigate global climate change [23].

The carbon storage capacity in agroforestry varies across species and geography [17]. Trees and shrubs in different land use systems act as carbon sinks. They absorb carbon (as CO_2) through photosynthesis and store it in their aboveground and belowground biomass. This process is called 'carbon sequestration'. IPCC [9] described carbon sequestration as the process of removal of carbon from the atmosphere and stored it in the biosphere. Moreover, the amount of carbon in any land use system depends on the structure and function of different components within the systems put into practice [1, 24]. The developing countries are bearing the maximum brunt of global warming and climate change, although their contribution to greenhouse gas emissions is much less than that of the developed countries.

It is, therefore, important that countries like Bangladesh to take serious steps which contribute in fighting climate change through the role of land use practices to mitigate climate change. The establishment of agroforestry based land use system will help in substantial and productive agriculture and climate change mitigation. However, in Bangladesh, the amounts of carbon sequestration by different land use system are unknown. The study was performed

to assess the potentiality of different Agroforestry related land use systems for carbon sequestration in the Northern region of Bangladesh.

Materials and Methods

Study Area and observations

The study was conducted in the northern part of Bangladesh located in the districts of Dinajpur. A stratified random sampling method was used in a randomized complete block design (RCBD) with four (4) replications as representative areas where different agroforestry related land use systems like homestead agroforestry, cropland agroforestry, orchard based agroforestry and road side plantation were practiced. Indeed, Dinajpur district includes three Agro-ecological Regions: Old Himalyan Piedmont Plain (AEZ-1), Tista Meander Flood Plain (AEZ-3) and Level Barind Tract (AEZ-25) and the ecosystems vary among the AEZs. Therefore, one site from each of the AEZs was selected. So, the study consist of six (6) land use systems (viz; Boundary crop land, single roadside plantations, double roadside plantations, homestead agroforestry, litchi orchard and mango orchard) and three (3) agro-ecological zones (viz. AEZ 1, AEZ 3 and AEZ 25). So, twenty four observations were recorded from each AEZ having total of seventy two (72) observations. Seven (7) years aged Eucalyptus tree was selected as an experimental tree in cropland and Roadside plantations. Similarly, same age was also considered in case of Orchard. In homestead, age was not used due to high variability and species diversity. Hence, only matured trees with diameter greater than 5cm (dbh) were considered for this experiment. Leaf litter, herb, grass or rice biomass was sampled using 1×1m quadrant method.

Tree Biomass Estimation

The biomass of tree is the sum of aboveground and belowground biomass content. For accurate measure of biomass in tree, it has to be felled. To avoid this, the standing woody biomass has been estimated using important growth parameter such as DBH and height. Tree height and DBH are the most common independent variables needed for the estimation of tree volume [2].

Aboveground biomass estimation (AGB). The aboveground biomass (AGB) has been calculated by multiplying volume of biomass and wood density; the volume was calculated based on diameter and height [19]. In this system, the following allometric equation for estimating biomass (kg per tree) of tree diameter 5–60 cm of different zones developed by [5] was used:

$$(AGB)est = 0.0509 \times \rho D2H,$$

where (AGB)est – Estimated aboveground tree biomass (kg per tree), D – diameter at breast height (DBH) (cm), H – tree height (m), ρ – Wood specific gravity (Mg m^{-3}) [5].

Belowground Tree biomass (BGB). Belowground tree biomass (BGTB) of trees was calculated by multiplying the above ground biomass (AGTB) with a default value of 0.26, provided by [8] as a factor of root: shoot ratio. Average root biomass content of all trees was 26% of aboveground biomass:

$$Below\ ground\ biomass = \\ = Aboveground\ biomass \times 0.26.$$

Total Biomass. Total tree biomass (TTB) is the sum of the above and below ground biomass [25]:

$$Total\ biomass = AGB + BGB.$$

Estimation of carbon stock in trees (t C/ha). Generally, for any plant species 50% of its biomass is considered as carbon storage [20]:

$$Carbon\ Storage = Biomass \times 0.5.$$

Estimation of carbon stock in Leaf litter, herb, and grass (LHG) or under stories biomass (t C ha^{-1}). The carbon content in under stories biomass (LHG) was calculated by multiplying with IPCC [2006] default carbon fraction of 0.47:

$$LHG\ (kg\ m^{-2}) = Biomass \times 0.47.$$

Estimation of Carbon Sequestered (t ha^{-1}). To estimate carbon sequestration of crops and trees the biomass carbon was multiplied with a factor of 3.67 for all species a formula used by Rajput [22]:

$$Estimated\ Carbon\ sequestration\ (t\ ha^{-1}) = \\ = Biomass\ carbon \times 3.67.$$

Total Land use carbon sequestration (t ha^{-1}). In order to achieve the total carbon sequestration by a particular land use system, total of trees and belowground litter fall, shrubs, herbs or rice were summed [21]:

$$Total\ land\ use\ carbon\ sequestration = \\ = Tree\ CO_2\ sequestration + \\ + LHG\ CO_2\ sequestration.$$

Estimation of Economic Value of Carbon Credits (US$ t ha^{-1}). One ton of net sequestered or mitigated carbon dioxide from plant biomass in a land use is equal to one carbon credit. Therefore, total carbon credit in a land use systems was calculated from CO_2-eq values of retained biomass in respective land use systems. The carbon credits were calculated from the total land use carbon sequestration from tree and crop biomass using the guidelines of IPCC in 1996. However, according to Vivan [26] the monetary value of one ton CO_2 is equivalent to US$15. In this study, the value of Vivian [26] was used. All data were statisti-

Table 1

Tree biomass and carbon stock of different land use systems

Land Use System	TH (m)	DBH (cm)	AGB (kg per tree)	BGB (kg per tree)	TTB (kg per t ree)	AGCS (kg per t ree)	BGCS (kg per tree)	TTCS (kg per t ree)
Boundary Cropland (T_1)	11.32b	13.52e	63.48cd	16.51bc	79.99cd	31.74cd	8.25cd	39.99cd
Single Roadside (T_2)	14.23a	16.31c	116.75a	30.35a	147.10a	58.37a	15.18a	73.55a
Double Roadside (T_3)	14.53a	15.12d	101.95ab	26.51a	128.46ab	50.98ab	13.25ab	64.23ab
Homestead Plat (T_4)	10.21b	13.02e	53.23d	13.84c	67.07d	26.61d	6.92cd	33.53d
Litchi Orchard (T_5)	5.86c	21.12b	79.81bc	0.75b	100.56bc	39.91bc	10.38d	50.28bc
Mango Orchard (T_6)	6.94c	22.24a	105.49a	27.42a	132.92a	52.75a	13.71a	66.46a
CV%	8.3	7.3	17.4	17.4	17.4	*17.4*	*17.4*	*4.5*

In a column, figures having similar letter(s) do not differ significantly where as figure's bearing different letter(s) differ significantly (as per DMRT)

cally analyzed using computer package R-studio and MS Excel 2007.

Results and Discussion

Tree biomass of different Land use systems. The study found that the total tree biomass (TTB) significantly varied with the land use systems (Table 1). The highest TTB (147.1 kg) per tree was found from Single Roadside (T_2) which was followed by Mango orchard (T_6) and Double Roadside (T_3). On the other hand, the lowest TTB (67.07 kg) per tree was recorded from Homestead (T_4) which was followed by Cropland (T_1) and Litchi Orchard (T_5). Wide variation of total biomass occurs due to heterogeneity of different land use systems. Khaki and Wani [11] estimated maximum total ground biomass (181.34 t ha^{-1}) in *Shorea robusta* pure forest, which was followed by Agrisilviculture system (46.02 t ha^{-1}) and lowest in natural grass land (4.47 t ha^{-1}).

Tree carbon stock of different Land use systems. The trend of carbon stock (TTCS) per tree was also followed as per tree biomass content, as shown in Table 1.

Total carbon sequestration of different land use systems (t C ha^{-1}). The study found that the total carbon sequestrations per hectares (TLUCseq) by the land use systems were highly influenced (Table 2). The highest TLUCseq (325.33 t ha^{-1}) was recorded from Double Roadside (T_3) which was followed by Single Roadside (T_2) and Homestead (T_4). However, the lowest TLUCseq (36.51 t ha^{-1}) was recorded from Cropland (T_1) which was followed by Litchi orchard (T_5) and Mango orchard (T_6). Several studies have been conducted to explore the effects of land use systems on Carbon sequestration and other biophysical factors that affect the systems [13, 14]. Kursten [12] stated that by adding trees in a system, it can increase the C storage capacity of the land use systems.

Economic value of carbon sequestration (US$ t ha^{-1}). The economic value of carbon sequestration provides market for GHG reduction in monetary val-

Table 2

Total Carbon sequestrations of different land use system

Land Use System	NT/ha	TTCS (tC ha^{-1})	LHG/RCS (tC ha^{-1})	TTCseq (t ha^{-1})	LGCseq (t ha^{-1})	TLUCseq (t ha^{-1})
Boundary Cropland (T_1)	158.9e	6.39d	3.56d	23.47d	13.05d	36.51c
Single Roadside (T_2)	420.0c	30.68b	11.52b	112.58b	42.29b	154.87b
Double Roadside (T_3)	1166.7a	75.43a	13.22a	276.83a	48.51a	325.33a
Homestead Plant (T_4)	988.9b	33.51b	7.69c	122.99b	28.22c	151.27b
Litchi Orchard (T_5)	216.6d	10.74cd	2.19e	39.62cd	8.03e	47.65c
Mango Orchard (T_6)	220.0d	14.64c	2.61e	53.72c	9.58e	63.30c
CV%	21.7	19.9	4.5	19.9	4.5	16.1

In a column, figures having similar letter(s) do not differ significantly where as figure's bearing different letter(s) differ significantly (as per DMRT)

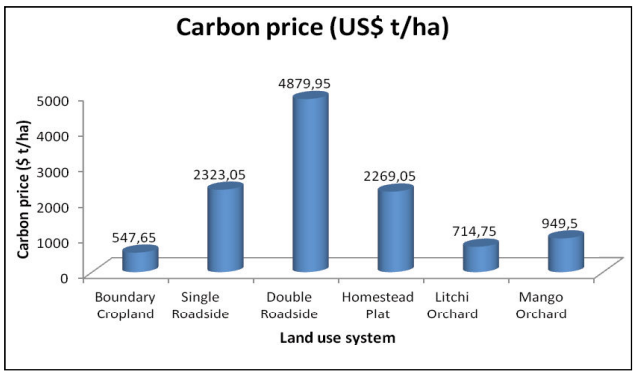

Figure. Economic value of carbon sequestration (US$ t ha^{-1})

ue (Figure). According to Vivian [26] one (1) ton of carbon was sold at US$15. So, the highest carbon price (4879.95 $ t ha^{-1}) was recorded from Double roadside (T_3) which was followed by single roadside (T_2) and Homestead (T_4). On the other hand, the lowest carbon price (547.65 $ t ha^{-1}) was obtained from Cropland (T_1) which was followed by Litchi orchard (T_5) and Mango orchard (T_6).

Conclusions

The finding of this study showed that different land use system had significant effects on biomass and carbon accumulation. Planting of multipurpose tree species in non-forest land like cropland, roadside, homestead etc. can serve a dual purpose by promoting carbon sequestration and production of non timber forest product for local people. The present investigation finds out that seven (7) year old Eucalyptus plantation in double roadside strip gave the highest sequestration ability of CO_2 due to its high biomass stand density. Finally, it may be concluded that since forest plantations cannot be extended to many large areas of Bangladesh due to high population pressure and demand of agricultural land, roadside agroforestry land use system will be a better option for larger tree plantation coverage and reduction in GHGs effects.

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COPING WITH FLASHFLOOD UNDER CHANGING CLIMATE IN NORTH-EASTERN HAOR AREAS OF BANGLADESH: POTENTIALS OF PROMISING CROP PRODUCTION PRACTICES

Md Anwarul Abedin[1]*, Umma Habiba[2]

[1]Department of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh; email: m.a.abedin@bau.edu.bd
[2]Ministry of Agriculture, Dhaka, Bangladesh
Email: m.a.abedin@bau.edu.bd (*corresponding author)

Haors are large bowl shaped floodplain depressions and one of the most important agro-ecological zones in Bangladesh. However, rice production in this area has been severely impacted by recent events of frequent early flashfloods. Many experts have linked the changes of flooding time and duration in haor area to global climate change. Farmers need short duration, relatively tall, lodging tolerance and non-shattering rice varieties to cope with the flashflood. With this contrast, this study is conducted in Tahirpur and Biswambarpur upazila of Sunamganj district to examine occurrence time and duration of flashflood; identify flashflood coping crop production practices; and finally investigate relationship between socio-economic characteristics of farmers and their flashflood coping crop production practices. Hence, this study utilizes a set of approaches viz. structured questionnaire survey, key informants interview with stakeholders and focus group discussions to get primary data and secondary data also collects to conceptualize the problems. Results reveal that short duration, varietal diversification, tall plant type of rice varieties are found popularly used practices in haor area. Although other coping practices like harvesting of rice at 80 percent maturity, early transplanting, aged seedling and rabi crops have substantial impact in coping flashflood but they are not extensively practiced. Study also reveals that education levels of farmers have highly positive and significant relationship with flashflood coping crop production practices; high coping practices are observed in educated farmers. In order to increase coping ability of farmers of farm practices, it is utmost important to link between government and development agencies to provide adequate technical support, extension service, education, income generating opportunity and water conservation measures.

Keywords: *Climate change, flashflood, coping mechanism, crop production practices, Haor Bangladesh.*

Introduction

Haors with their unique hydro-ecological characteristics are large bowl shaped floodplain depressions located in the north-eastern region of Bangladesh covering about 1.99 mln ha of area and accommodating about 19.37 mln people [2]. Adding together, there are about 423 small and large haors in the northeastern part of Bangladesh occupying about one-sixth area of the country [1]. The productivity of this haor basin has contributed to be food surplus of this region and there is a potentiality for further increase of land for agriculture. But the recent change in timing of flood and pattern is affecting the livelihood of the haor people. The haor basin is close to the Indian border and Meghalaya Hills where deforestation (natural and manmade) is happening everyday. In addition, climatic changes have also contributed in degrading the eco-system that causes severity of flash floods – sudden onrush of water into the haor areas [3]. The flash flood generally occurs after mid April due to heavy rainfall in the hills of Meghalaya, India. In recent years, flash flood hits the haor areas fifteen days earlier than thirty to forty years back. Thirty years before, flash flood took three to five days to reach the bordering areas and seven to fifteen days to reach the other haor areas inside the country while in the present situation, only one day and three to five days respectively, are needed. Forest in the hilly areas and haor basin used to slow down the flow of water and more water were seeped into local soils for storage. Siltation in rivers, canals, and haors has raised the haor and riverbeds. As a result, the rivers and canals cannot hold much water and severity of flood intensifies.

The haor is a single crop area and rice in this vast basin covering about 97% of the total cropped area. Few other winter crops are also sporadically grown to the bank side of the haors. In order to have higher yield the local farmer recently switched to cultivate HYV rice (BRRI dhan 29, BRRI dhan 28 etc.)

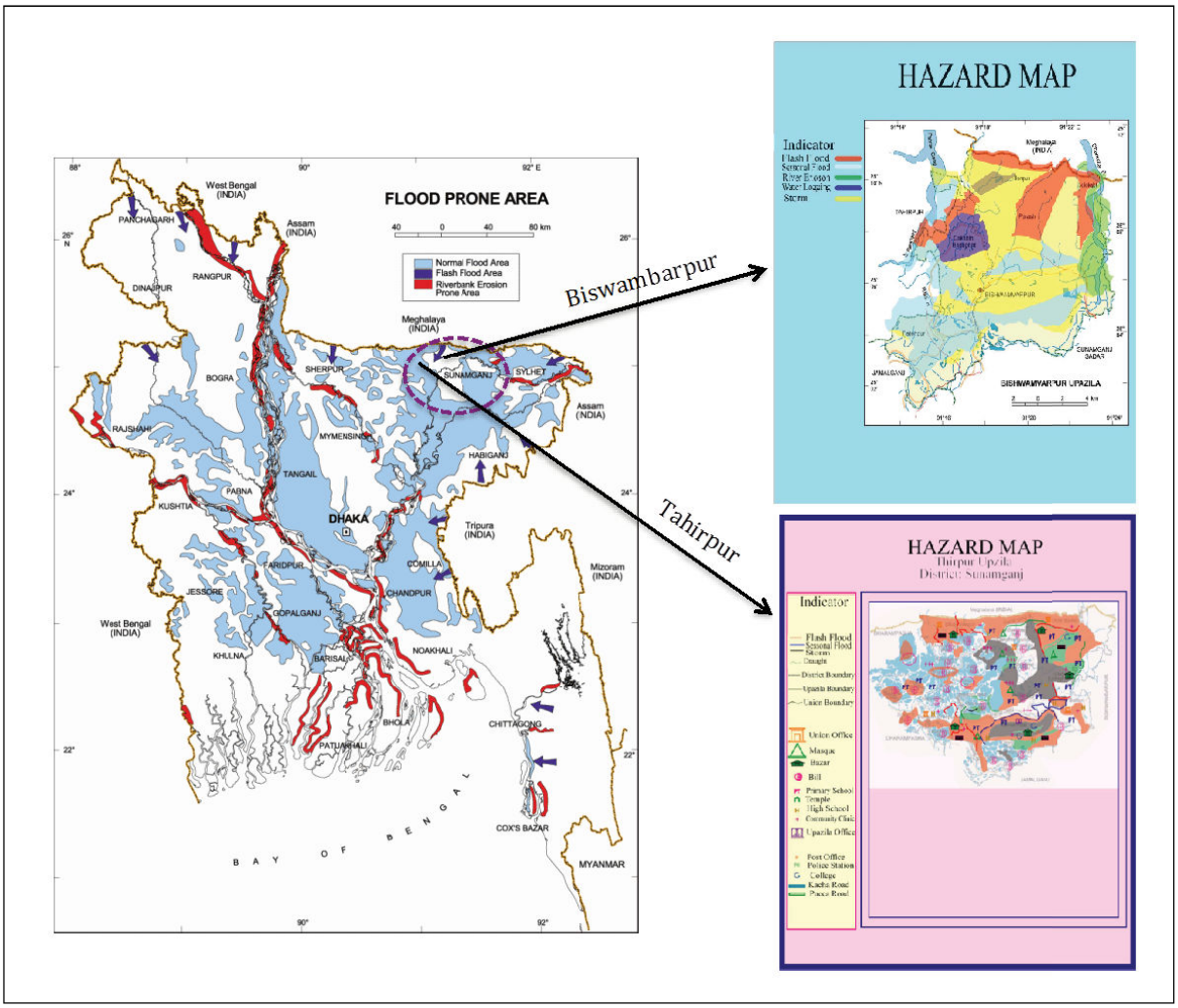

Figure 1. Location of the study area in Sunamganj district of Bangladesh

instead of local boro rice variety. But the longer duration and dwarf plant height characteristics of these varieties often become the victim flash flood. As a result, farmers cannot harvest potential yield of these rice varieties. On the other hand, climate variability and change increased precipitation early in the season make flash floods more unpredictable and damaging, affecting livelihoods and food security of thousands of haor residents. In 2003 over 80 percent of rice amounting to 0.6 million tons was completely damaged due to fashfloods. Sometimes, the flashflood comes early, just before the rice harvesting and during that time the people of haor basin, do not even get the time to harvest their crops. In many cases, it has been found that this part of Bangladesh losses 100% of its crops.

To cope with flashflood many farmers grow cereals, vegetables, spices, pulses and tuber crops successfully during rabi season in the haor basin and harvested much earlier than boro rice. To minimize the damage, haor farmers need short growth duration, relatively tall, lodging tolerance and non-shattering rice variety. Practicing of transplanting time in case of rice cultivation is always regarded as good practice against flash flood. With this contrast, this study is conducted to examine occurrence time and duration of flashflood; identify flashflood coping crop production practices; and finally investigate relationship between socio-economic characteristics of farmers and their flashflood coping crop production practices that would help in formulating effective extension program to cope with the situation in a sustainable way.

Study area and population

The study is conducted in two Upazilas namely Tahirpur and Biswambarpur of Sunamganj district. Ten villages from these two upazila are selected randomly for the study. All of the farmers of these villages are constituted the population of the proposed research. Twenty percent of them are selected as the sample farmers.

Table 1

Study approach

Instrument and method of data collection	Target group
Key Informants interview (30)	Government officials, local leader, NGO people, School and College teacher, Elected member, Mosque Imam
Focus group discussion (8)	Government officials, NGO people, Farmers, community leader, mosque imam, Journalist
Questionnaire survey at institutional level (10x2 = 20)	Government official
Questionnaire survey at community level (90x2 = 180)	Mainly Farmers

Methodological Approach

The state of the art methodologies are applied in order to get a comprehensive view of the complex issues of the flashflood coping crop production practices of haor farmers (Table 1). Firstly, research related literature have been collected to gain preliminary understanding of flashflood and related issues. Secondly, focus group discussions (FGD); key informants interviews (KII) and semi-structured questionnaire have been conducted through various stakeholders in the study area to get primary data. All the collected data then are summarized and scrutinized carefully and analyzed by MS-Excel and then presented in textual, tabular and graphical forms to the present status of the studied area.

Results and Discussion

Flashflood is a common phenomenon in northeast haor of Bangladesh and this study discloses how promising crop production practices of farmers helps to secure Boro rice from the damage of flashflood in the study area by using questionnaire survey, FGD and KII.

Occurrence and duration of flashflood

Northeastern hoar areas of Bangladesh are prone to flashflood. Flashfloods may occur in this region from the surrounding hilly region of India at least two or three times a year. Boro rice cultivation is severely damaged via early flashflood. Furthermore, Aman rice is also affected by heavy rainfall in this region via late flashflood.

Research results showed that crop loss increased with the increase of frequency and duration of flashflood comes early in April (Table 2). Data also revealed that duration of flashflood in 2014 and 2015 were only for few days and crop damages of these two years were also less in compare to the recent years. In 2017, Flashflood in Tahirpur upazila approached earlier than Biswamvarpur upazila and the duration is more prolonged in Tahirpur than Biswamvarpur. However, the crop loss is more or less similar in both two upazila.

Table 2

Occurrence and duration of flashflood in the study area

Location	Year	Duration of 1st flashflood	Duration of 2nd flashflood	Crop loss (%)
Tahirpur	2017	27 Mar – 24 April		95–100
	2016	08–14 April	23 April – October	75–100
	2015	06–10 April	10–16 April	0–40
	2014	14–18 April	----	0 – 15
Biswamvarpur	2017	2 April	Late April to October	80–100
	2016	08–14 April	October	70–75
	2015	06–10 April		0–30
	2014	14–18 April	----	0–15

Table 3

The extent of application of flashflood coping crop production practices, %

Promising coping practices	Frequent	Occasionally	Rare	Not at all
1. Use of short duration rice variety	80.1	10.8	4.0	5.1
2. Early transplantation	2.0	10.9	30.1	57.0
3. Local rice varieties	20.0	11.0	7.3	61.7
4. Aged seedlings	10.0	12.0	20.3	57.7
5. Varietal diversification	71.0	17.1	8.2	4.7
6. Non-shattering rice variety	47.5	38.6	13.3	0.6
7. Tall plant type rice variety	55.1	16.5	13.3	15.2
8. Crop diversification	5.7	11.4	15.8	67.1
9. Harvesting at 80% maturity	25.9	12.7	8.9	52.5

Extent of application of flashflood coping crop production practices

Focus group discussion and key informant interview are utilized at Tahirpur and Biswamvorpur Upazilas of Sunamganj district and nine promising cultivation practices are identified as the measures to cope with flashflood. After identification of the practices, farmers are asked to give their opinion about the extent of application of the selected nine-flashflood coping crop production practices in their crop field. A four-point scale of responses viz. 'frequent use', 'occasionally use', 'rare use' and 'not at all use' are used in this study and four levels of weight are assigned viz. 3, 2, 1, and 0 for the answers namely 'frequent use', 'occasionally use', 'rare use' and 'not at all use', respectively.

Table 3 illustrated that farmers of the affected area frequently used (80.1%) short duration rice variety as promising option against flashflood. Some local rice varieties such as Guchi/ Shail, Tepi and Lakhai are used to transplant as short duration rice variety where as only BRRIdhan28, a high yielding rice variety are considered as short duration rice variety in the study area.

Available local rice varieties grown in the haor areas are tall and non-shattering in nature but their yield is low (approximately 2.2 t ha^{-1}). However, these varieties are good taste to eat, short duration and sub-mergence tolerance to some extent, for which half of the haor farmers transplanted these varieties in the deep haor areas.

It is also notable that, haor farmers (57%) neither transplanted aged rice seedling nor they followed crop diversification as a mean of flashflood coping mechanism. Farmers argued that aged seedlings shorten the life cycle of rice, therefore, they could not get better yield.

Correlation coefficient (r) analysis

The data in Table 4 showed that the positive significant correlation of formal education of the respondents with flashflood coping crop production practices ($r = 0.730^{**}$, $p > 0.05$) clearly points out that with the increase of the level of formal education of the haor farmers the flashflood coping practices also increases as formal education plays a key role in the adaptation of farming practices under climate change condition [4].

Conclusion

In conclusion, it can be said that haor farmers have their own mechanism to cope with flashflood since long past. However, Results revealed that short duration, varietal diversification, tall plant type of rice

Table 4

Correlation analysis of factors influencing flash flood coping crop production

Variables	Correlation coefficient (r)
Education level	0.730**
Family size	0.342**
Annual family income	0.081
Attitude vs embankment as means of crop protection	0.611**

** = Significant at 1 percent (0.01) level with 180 degree of freedom

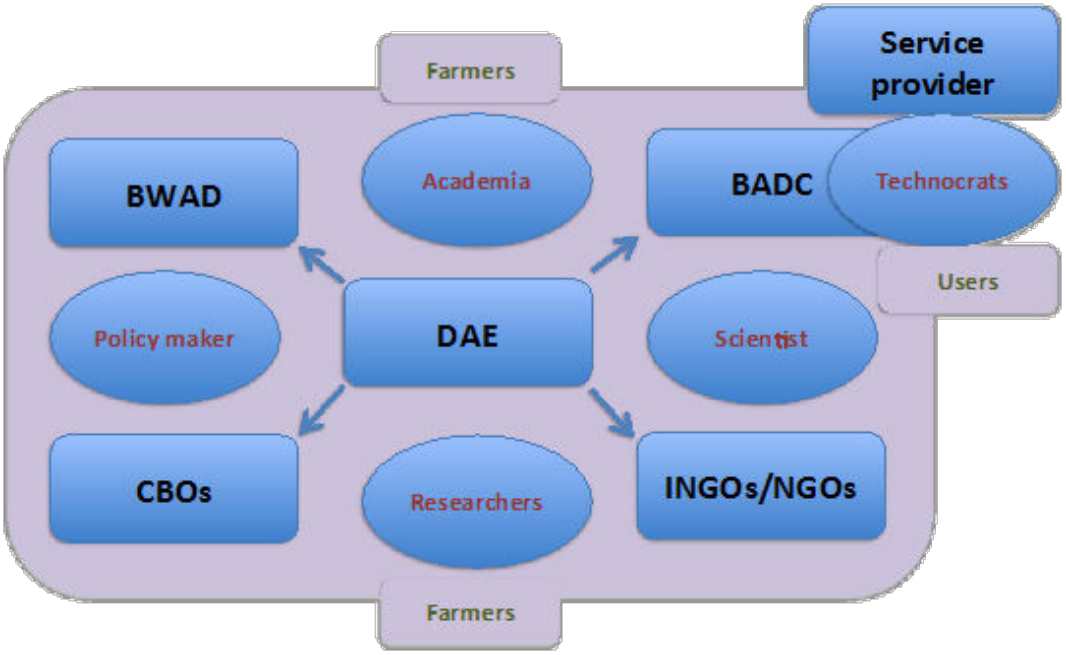

Figure 2. Linkage among different stakeholders to cope with flashflood under changing climate

varieties are found popularly used practices in haor area. Although other coping practices like harvesting of rice at 80 percent maturity, early transplanting, aged seedling and *rabi* crops have substantial impact in coping flashflood but they are not extensively practiced. Study also revealed that education levels of farmers have highly positive and significant relationship with flashflood coping crop production practices; and high coping practices are observed in educated farmers. In order to increase coping ability of farmers of farm practices, it is utmost important to link between government and development agencies to provide adequate technical support, extension service, education, income generating opportunity and water conservation measures (Figure 2).

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AGROFORESTRY BIOTECHNOLOGY FOR SUSTAINABLE AGRICULTURE ON MARGINAL LANDS

Sang-Soo Kwak
Plant Systems Engineering Research Center, Korea Research Institute of Bioscience and Biotechnology (KRIBB), Daejeon, Korea
Email: sskwak@kribb.re.kr

The dramatic increase in the global population combined with rapid industrialization in developing countries has placed great strains on global food and energy supplies. The UN-FAO estimated that the world population will exceed 9.7 billion in 2050. If we use energy and food at the present rate, we will need more than 3.5-times the current energy supply and 1.7-times the current food supply in 2050. To cope with these global crises in food and energy supply as well as environmental problems, the development of new eco-friendly industrial plant varieties for growth on marginal lands is urgently needed to ensure sustainable development. Plant biotechnology can be used as a tool to maximize plant productivity by introducing stress tolerance genes and metabolic genes responsible for increasing yield and improving functions. In the presentation, recent results on transgenic plants (sweetpotato, alfalfa and poplar) with enhanced tolerance to abiotic stresses are introduced. Sweetpotato represents an attractive crop that can be used to help solve the global food and environmental problems as an industrial bioreactor. Alfalfa is one of important legume forage crops on the global marginal lands. Poplar trees provide raw materials, help maintain biodiversity, protect land and water resources, and help mitigate the effect of climate change on global marginal lands.

Keywords: *Sustainable agriculture, agroforestry biotechnology, food security, abiotic stress, sweetpotato, alfalfa, poplar.*

Why biotechnology is essential to cope with three UN environmental conventions?

There are three UN environmental conventions such as Biodiversity, Climate Change and Combating Desertification. For example, the causes of desertification/land degradation derive primarily from human activities such as overgrazing, deforestation and the improper management of soil and water by the local poor people living on marginal land. Thus agroforestry biotechnology will be important to increase local people income and thereby combat desertification/land degradation in an eco-friendly manner. This concept should be strongly supported as part of the United Nations (UN) "Decade for Deserts and the fight against Desertification" (UNDDD, 2010~2020) and UN Sustainable Development Goals (UN SDGs, 2016~2030).

Our research team is focusing on development of industrial biotech plants (sweetpotato, alfalfa and poplar) for sustainable agriculture on global marginal lands including desertification areas. Industrial biotech plants on marginal lands can produce high value-added biomaterials as well as to cope climate change, biodiversity and combating desertification in a blue ocean manner. Here, our recent results are introduced in terms of possible biotechnological applications for molecular breeding for sustainable development on marginal lands.

Sweetpotato biotechnology

Sweetpotato [*Ipomoea batatas* (L.) Lam] represents an attractive crop that can be used to help solve the world's food and environmental problems in the 21st century; this crop can be used as an industrial bioreactor to produce various high value-added materials, including bio-ethanol, functional feed, and antioxidants, via molecular breeding. Sweetpotato plants have high water use efficiency among starch crops, and help reduce soil erosion. All parts of the sweetpotato plant can be used for human and animal consumption. Due to its rich nutritional content combined with its wide adaptability to marginal lands ranging from tropical to temperate zones, sweetpotato has great potential for preventing malnutrition and increasing food security in developing countries [1].

The nonprofit Center for Science in the Public Interest (CSPI) described sweetpotato as one of ten superfoods for better health, since it contains high levels of low molecular weight antioxidants such as carotenoids and vitamin C, as well as dietary fiber and potassium (2016). Carotenoids benefit human

health by acting as dietary antioxidants and alleviating aging-related diseases. Carotenoids also serve as a dietary source of provitamin A, making them essential components of the human diet, since humans are unable to synthesize vitamin A. According to a United States Department of Agriculture (USDA) report, sweetpotato can yield two to three times the level of carbohydrates as field corn, approaching the amount that sugarcane can produce in the US (2008). It would be worthwhile to begin pilot programs to investigate the feasibility of growing sweetpotato for ethanol production on marginal lands. Thus, rational metabolic engineering of low molecular weight antioxidants should contribute to the development of new sweetpotato cultivars with higher levels of nutritional antioxidants and abiotic stress tolerance.

Here, sweetpotato *Orange as* a target gene for regulating carotenoid homeostasis and increasing plant tolerance to environmental stress in marginal lands will be introduced [7]. *Orange* genes, which play a role in carotenoid accumulation, were recently isolated from several plant species, and their functions were intensively investigated. The *Orange* gene (*IbOr*) from sweetpotato helps maintain carotenoid homeostasis to improve plant tolerance to environmental stress. IbOr, a protein with strong holdase chaperone activity, directly interacts with phytoene synthase (IbPSY), a key enzyme involved in carotenoid biosynthesis, in plants under stress conditions, resulting in increased carotenoid accumulation and abiotic stress tolerance (8). In addition, IbOr interacts with the oxygen-evolving enhancer protein 2-1 (PsbP), a member of a protein complex in photosystem II (PSII) that is denatured under heat stress [2]. Transgenic sweetpotato plants overexpressing *IbOr* showed enhanced tolerance to high temperatures (47°C). These findings indicate that IbOr protects plants from environmental stress, not only by controlling carotenoid biosynthesis, but also by directly stabilizing PSII in all plant species [4].

Alfalfa biotechnology

Alfalfa (*Medicago sativa* L.), one of the most important legume forage crops, is widely cultivated throughout the world due to its significant economic value and excellent agricultural traits. As one of the highest-yielding forage crops, alfalfa has outstanding nutritional quality, with high levels of protein, minerals, and vitamins as well as well-balanced amino acids. Moreover, the nitrogen-fixing ability of alfalfa reduces the amount of energy required for its production and improves soil structure. In addition, alfalfa has deeper roots than most crops. This deep, vigorous root system allows alfalfa to adapt to various environmental conditions and increases its capacity to prevent soil erosion. Thus, alfalfa is considered to be a potential forage crop for use in areas subjected to environmental stress such as drought and high salinity. However, the pernicious effects of abiotic stress (such as salt and drought stress) still represent major limits to alfalfa production. To improve the adaptability of alfalfa to these environmental stresses, many studies focused on modifying various aspects of alfalfa plants, such as the activation of cascades of molecular networks involved in stress responses.

In an effort to improve the nutritional quality and environmental stress tolerance of alfalfa, we transferred the *IbOr* gene into alfalfa (cv. Xinjiang Daye) under the control of an oxidative stress-inducible peroxidase (*SWPA2*) promoter through *Agrobacterium tumefaciens*-mediated transformation [5]. Among the 11 transgenic alfalfa lines (referred to as SOR plants), three lines (SOR2, SOR3, and SOR8) selected based on their *IbOr* transcript levels were examined for their tolerance to methyl viologen (MV)-induced oxidative stress in a leaf disc assay. The SOR plants exhibited less damage in response to MV-mediated oxidative stress and salt stress than non-transgenic plants. The SOR plants also exhibited enhanced tolerance to drought stress, along with higher total carotenoid levels. The results suggest that SOR alfalfa plants would be useful as forage crops with improved nutritional value and increased tolerance to multiple abiotic stresses, which would enhance the development of sustainable agriculture on marginal lands [9].

Poplar biotechnology

Trees have great values as a source of essential elements for human living. They have unique characteristics, such as perennial growth, developmental phase changes, secondary growth and metabolism, and trees also exhibit resistance systems to extreme environmental conditions. Among the various tree crops, poplar occupies a prominent place as a model system for functional genomics studies. Poplar has many features that make the species a suitable model for forest biotechnology, such as fast growth, a relatively small genome, ease of vegetative propagation, facile transgenesis and tight coupling between physiological traits and biomass productivity. Of particular importance and convenience is the highly efficient genetic transformation system coupled with efficient regeneration of poplar that is unsurpassed by other tree crops.

Nucleoside diphosphate kinase 2 (NDPK2) is known to regulate the expression of antioxidant genes in plants. Previously, we reported that overexpression of Arabidopsis NDPK2 (AtNDPK2) under

the control of SWPA2 promoter in transgenic potato and sweetpotato plants enhanced tolerance to various abiotic stresses [6]. Transgenic poplar (*Populus alba* × *P. glandulosa*) expressing the AtNDPK2 gene under the control of a SWPA2 promoter (referred to as SN) was generated to develop plants with enhanced tolerance to oxidative stress. The level of AtNDPK2 expression and NDPK activity in SN plants following MV treatment was positively correlated with the plant's tolerance to MV-mediated oxidative stress. We also observed that antioxidant enzyme activities such as ascorbate peroxidase, catalase and peroxidase were increased in MV-treated leaf discs of SN plants. The growth of SN plants was substantially increased under field conditions including increased branch number and stem diameter. SN plants exhibited higher transcript levels of the auxin-response genes IAA2 and IAA5. These results suggest that enhanced AtNDPK2 expression affects oxidative stress tolerance leading to improved plant growth in transgenic poplar.

The flowering time regulator GIGANTEA (GI) connects networks involved in developmental stage transitions and environmental stress responses in *Arabidopsis*. However, little is known about the role of GI in growth, development, and responses to environmental challenges in the perennial plant poplar. Here, we identified and functionally characterized three *GI-like* genes (*PagGIa*, *PagGIb*, and *PagGIc)* from poplar [3] *PagGIs* are predominantly nuclear localized and their transcripts are rhythmically expressed, with a peak around zeitgeber time 12 under long-day conditions. Down-regulation of *PagGIs* by RNA interference led to vigorous growth, higher biomass, and enhanced salt stress tolerance in transgenic poplar plants. Taken together, these results indicate that several functions of *Arabidopsis GI* are conserved in its poplar orthologs, and they lay the foundation for developing new approaches to producing salt-tolerant trees for sustainable development on marginal lands worldwide.

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ROLE OF WEATHER MODIFICATION TECHNOLOGY IN CLIMATE CHANGE ADAPTATION: INDONESIAN CASE

Tri Handoko Seto*, Andi Eka Sakya, M. Bayu Rizky Prayoga, Faisal Sunarto
National Centre for Weather Modification Technology, the Agency for the Assessment and Application of Technology (BPPT), Indonesia
Email: tri.handoko@bppt.go.id (*corresponding author)

Climate change has caused unexpected weather and extreme climate which induces increase both frequency and scale of intensity of hydro-meteorological disasters. As a maritime continent and lies at the equator, Indonesia became one of the most affected countries by climate change. The event of El Nino in 2015 which costed up to 0.2% of GDP became a very typical case related to extreme climates. Instead of farmers are blessed by fertility due to surroundings seasonal regular periodicity and ring-of-fire, the seasonal period shows a shift in rainfall and drought periods in the last 60 years. It thus affects the cropping pattern and damage the soil fertility. In an effort to handle prolonged drought and its effect on forest and land fire prevention, the so-called rain making of Weather Modification Technology (WMT) is conducted. Basically, the cloud atmospheric intervention is stimulated by sodium particles, the process of which is left naturally. The use of WMT for other purpose is to intervene in potentially heavy rain and water shed recharge. Activities of WMT are being introduced to accommodate the adaptation of climate change process. Several examples of WMT successful delivery are presented.

Keywords: climate change, hydro-meteorological disaster, prolonged drought, Weather Modification Technology.

Introduction

Climate change has caused unexpected weather and extreme climate which induces increase both frequency and scale of intensity of hydro-meteorological disasters. As a maritime continent and lies at the equator, Indonesia became one of the most affected countries by climate change. The event of El Nino in 2015 which cost up to 0.2% of GDP became a very typical case related to extreme climates.

Instead of farmers are blessed by fertility due to surroundings seasonal regular periodicity and ring-of-fire, the seasonal period shows a shift in rainfall and drought periods in the last 60 years. It thus affects the cropping pattern and damages the soil fertility. As it has also been widely expected, the dry season is getting longer and the rainy season is getting shorter. The average total rainfall has even an increasing trend in several areas. When it enters dry season, which is tend to be longer recently, it induces hot spot and caused a bigger forest fire.

In an effort to handle prolonged drought and its effect on forest and land fire prevention, the so-called rain making of Weather Modification Technology (WMT) is conducted. Basically, the cloud atmospheric intervention is stimulated by sodium particles, the process of which is left naturally. The use of WMT for other purpose is to intervene in potential heavy rain and water shed recharge. The purpose of the current work is to give an idea of WMT, and to present several examples of WMT success delivery.

Weather Modification Technology

For more than two decades, the frequent occurrence of disasters related to global climate change issues has placed Weather Modification Technology as one of the most reliable alternative solutions to anticipate losses due to climate and weather-related disasters, especially haze and smoke disaster due to forest fire. WMT for the first time began to be utilized by the Government of Indonesia as efforts to overcome the smoke hazard due to massive forest fire disaster in 1997. Frequency of WMT utilization for the effort to overcome the smoke disaster from forest fire increased dramatically in the last decade, along with the increasing frequency and intensity of incidence of smoke disaster from forest fire and the increasing of losses caused by the that disaster. From 2009 to 2017, the implementation of WMT for forest fire mitigation is routinely carried out every year in a number of provinces prone to forest fire disaster on the island of Sumatra and Borneo.

Weather Modification Technology is a human intervention in the process of rain formation in the cloud. The process of collision and coalescence of cloud drops with particles of cloud-seed material that

has changed from solid to liquid. As a result of this intervention, the process in the cloud will be more efficient than the natural. Intervention is done by injecting a material called seeding agent into the cloud. In the high layers, moisture in moist air condenses at the condensation core into very small cloud drops and the bundle is seen as a form of cloud. Naturally, core-condensation is present in the atmosphere. Through a process within the cloud and supported by the continuous entrainment of water vapour from the environment beneath the cloud base, the clouds grow into large clouds of rain and then produce rain.

When forest fires happen, the atmosphere contains very little moisture (low amount in relative humidity). In addition, the burning of biomass causes the population or the amount of core-condensation in the atmosphere to increase by more than 300% [6]. This condition led to competition for water vapour which at that time was not very much in number. This situation makes it very difficult to form clouds. Even if there is a cloud, this cloud cannot grow bigger so it is difficult for the occurrence of rain. At the time of forest fires the weather conditions are usually stabilized and solar radiation to the earth is reduced. Because of the stable weather conditions, the smoke caused by forest fires and land is difficult to be wasted into the sky, causing longer distances to visibility and the air pollution increasingly disturbing respiration.

At the time of smoke conditions getting thicker like that, then the rainfall play vital role to clean up the air from the smoke layer to improve the radiation conditions. As the radiation improves, the weather becomes unstable so that the cloud formation process is running normally. For making that condition happen, Weather Modification Technology becomes very important to be able to convert the potential clouds into rain for making the area of forest fire become wetter. When the atmosphere above an area of forest fire becomes favourable with the entry of moist air periodically, the clouds in this area will grow and develop. It is in these conditions that WMT's role is very effective, that is accelerating rainfall process to increase rain intensity, expanding rainfall area and prolonging duration of rain.

Weather Modification Technology has some effectiveness compared to other technologies in fire extinguishment for haze and smoke disaster prevention due to forest and land fires. Firstly, no technology is capable of extinguishing forest and land fires in large escalations, except by rain. WMT provides an alternative way to accelerate the natural process of rain in several areas which are vulnerable to forest fire disaster in the dry season.

Secondly, under the conditions of concentrated smoke, smoke is not only harmful to humans. Concentrated smoke is also "unfriendly" to the occurrence of rain in 2 (two) terms:

a. Concentrated smoke blocks the radiation from entering the earth's surface. As a result the earth's surface temperature is not warm enough to create an unstable vertical profile of the air temperature. On the other hand, the vertical profile of the unstable air temperature is the medium for the formation of clouds due to convection activity or lifting the air period to occur condensation. Finally, the cloud becomes difficult to form and of course the rain does not happen.
b. When there are clouds in an area within dense smoke layer (generally the clouds on this area come from other areas carried by the wind, in meteorological terms called advection), the concentrated smoke will consume the water vapour and clouds so the cloud will always be in the first/initial phase. Clouds in the initial phase are marked with small clouds of grain. As a result, the rain process will be very difficult to happen. The concentrated smoke of forest and land fires is dominated by very small particles less than 2 microns of about 2000 particles cm^3.

Thirdly, WMT or artificial rain will play an important role in improving the efficiency of the rain process because it is able to change the clouds that are in the early phase entering the adult phase until mature. WMT is done by sowing large hygroscopic seeding materials (UGN: Ultra Giant Nuclei, 10-50 micron). Collisions and coalescence are always followed by a chain effect (known as the *Langmuir chain-reaction*) that causes droplet enlargement to expand rapidly and precede the occurrence of rain within a cloud [5].The presence of this seeding material will increase collision and coalescence efficiency, which is a key to the process of rain on warm clouds that often grow in the tropical area. For information, clouds in the early phases have collision efficiency below 10%. Meanwhile, cloud seeding can increase efficiency to about 80%.

Examples of WMT success delivery

From a number of WMT utilization experiences for forest fire mitigation purposes, there is still room to improve the effectiveness of these technologies in order to provide optimum results. Weather Modification Technology operations are often constrained if the atmospheric conditions around the affected areas have been very dry so that it is difficult

to meet the presence of potential clouds worthy for seeding. Moreover, several studies states if the smoke haze conditions are so thick, they block the radiation of sunlight from entering the surface which makes it difficult to convection process as an early stage of the cloud growth phase [3, 4]. This is why haze usually is associated with regions of large-scale stagnation. With both vertical and horizontal mixing at a minimum, whatever aerosols may be present will accumulate at first locally and then regionally over those areas experiencing minimal air flow, sunshine, and high relative humidity [2]. The thickness of the smoke haze also causes low visibility so it is not safe for flight. Under such conditions, the implementation of Weather Modification Technology operations is often constrained because the aircraft cannot fly to conduct cloud seeding activities.

Based on the above description, it can be concluded that the initial problem of smoke and haze hazard due to forest fire triggered by drought factors. The emergence of this disaster can actually be detected earlier when there is an indication of drought in the vulnerable area, especially peat land area. Thus, the forest fire disaster can be prevented/anticipated by trying to keep the water reserves on peat soil can be maintained so as not to experience drought. WMT operation will be more effective if it starts when the peatland shows a drought trend, characterized by an increased tendency of hotspots. WMT's target on the situation is not to extinguish the fire point in the field, but rather to maintain the level of wetness in the area of peatland (rewetting). With the maintenance of soil moisture in peatland areas, the potential for fire in peatland areas is also decreasing.

Since it was first implemented in 1979, until 2017 it has been recorded that 39 projects of WMT is used as one of the technology to reduce the smoke and haze hazard due to forest and land fire events in Indonesia. WMT operations are generally conducted during the transition season until the beginning of the rainy season, May to October, in some areas which are vulnerable to forest and land fire. In its implementation, WMT is focused to make forest and land fire vulnerable area become wet so that haze and smoke potential can be reduced. If the conditions have entered the peak of the dry season, by artificial rain that makes peat land become wetter WMT also serves as a technology to prevent the expanding area of forest fires.

The implementation of WMT is often operated in several provinces in Indonesia with considerable peat land cover, such as Riau, South Sumatra, Central Borneo and West Borneo. The peatlands in those provinces are potentially highly flammable. When it has entered the peak of the dry season, the potential of peat smouldering will be enormous. Until now forest and land fires in peat land are very difficult to be overcome. Fire under deep peat is difficult to be detected, so it is very difficult to know whether it is completely extinguished or not. For that, the role of WMT in modifying the weather by maximizing the potential for rainfall can provide very helpful influences in forest and land fire disaster prevention. By preserving the wetness of the peat land through rain, the potential for fire and its expansion will be reduced.

Some of the latest WMT operations such as in 2017 have a good effect in the context of forest and land fire mitigation. During 2017, WMT for disaster management of haze smoke caused by forest and land fires was carried out in Riau, South Sumatra, Central Borneo and West Borneo provinces. The results of Weather Modification Technology activities in some of these provinces succeeded in suppressing the number of hotspots, so as to prevent massive forest and land fire events in Indonesia. The success of WMT's operation could be evaluated by the number of hotspots. Recorded number of hotspots in Riau Province for example, during the implementation of WMT in 2017 can be pressed in the amount of 29 hotspots during August-September (MODIS hotspot data with confidence level $\geq$ 80%). The number has decreased significantly when compared to previous years. For comparison, the average number (2006-2016 historically) of hotspots in the same period in Riau Province reached more than 400 hotspots [1].

Another example of the success of WMT in disaster management of smoke caused by forest and land fires can be evaluated by increasing the value of rainfall during WMT period in weather modified areas. Each WMT activity by doing cloud seeding in the target area will be calculated. The calculated is done to find out how much rainfall that managed to fall to the surface. Another example in 2017, during WMT's operation in Riau Province, a total of 283 mm of rainfall during August-September, which is the peak of dry season in Riau area, is well calculated as the effect of Weather Modification Technology. By calculating the extent of the treated area of cloud seeding, the total rainfall of 283 mm is equivalent to 350 million m^3 of water produced through the weather modification process. Considering it is the peak of dry season, those numbers could be briefly describe as the effect of how Weather Modification Technology is one of the reliable technologies in forest and land fire disaster management.

Conclusion

In current work, activities of WMT are being introduced to accommodate the adaptation of climate change process. Several examples of WMT success delivery are briefly presented. At the next step assessment of the result on the economic benefit and socio-impact within the perspective of adaptation to climate change will be described.

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CLIMATE CHANGE: CHALLENGES FOR AGRICULTURAL ENVIRONMENT

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SALINITY INTRUSION AND COASTAL AGRICULTURE: ADAPTATION STRATEGIES USING SALT-TOLERANT PLANT-GROWTH PROMOTING RHIZOBACTERIA FOR SUSTAINABLE FOOD SECURITY

Shahnaz Sultana, Sumonto C Paul, Muhammad Manjurul Karim*
Department of Microbiology, University of Dhaka, Dhaka, Bangladesh
E-mail: manjur@du.ac.bd (*corresponding author)

The salinity level in the coastal ecosystem and agricultural lands is being increased gradually due to the climate change effect, and Bangladesh is no exception to suffer salinity intrusion threatening its food security. In order to bring the salinity-affected lands under agriculture, the application of salt-tolerant, plant growth-promoting rhizobacteria (PGPR) as biofertilizer could be a method of choice. The current research reports the isolation of a salt-tolerant PGPR, identified as Bacillus aryabhattai MS3 from a coastal rice field of Bangladesh. Under laboratory condition, the strain showed profound plant growth-promoting activities: nitrogen fixation, production of indole acetic acid (IAA), phosphorus solubilization and siderophore production under 200 mM salinity. While in soil, rice growth under non-saline condition was comparable in between biofertilizer-added and control pots, the scenario was statistically significant when challenged with salts, 46% and 8% survival were recorded respectively. The PGPR supported the plants under salinity by increasing the availability of nutrients, accelerating IAA and chlorophyll production, enhancing proline accumulation, and decreasing malondialdehyde formation. The semi-quantitative reverse transcription-PCR demonstrated that the bacterium selectively up-regulated the plant expression of NHX1 gene under salinity, thereby conferring tolerance to salt stress. Overall, the application of salt-tolerant biofertilizer could be a non-transgenic innovation to support plant growth for coastal lands under changing climate conditions.

Keywords: *Bangladesh, plant growth-promoting rhizobacteria, salinity, salt-tolerance.*

Introduction

Under the ongoing changing climate conditions, saltwater intrusion is expected to worsen the fertility of coastal agriculture around the world, and Bangladesh being a flat and low-lying country is no exception. Once crossed the threshold limit, salinity conditions may decrease seed germination either by creating osmotic potential or by toxic effects, leading to retardation in plant development. Genetic engineering and molecular marker assisted breeding technologies are being used to develop saline tolerant crops, while the use of alternate technologies through non-transgenic approaches, like application of plant growth-promoting rhizobacteria (PGPR) for ameliorating abiotic stress is gaining importance and momentum for consideration [12]. The isolation of a salt-tolerant PGPR, identified as *Bacillus aryabhattai* MS3 from a coastal rice field of Bangladesh and its effect on growth of rice plants in the form of biofertilizer under regular and salt-stressed condition, are presented in current work.

Methods

Soil, water and sediment samples collected from the rice fields of salinity-affected coastal region of Bangladesh were subjected for bacterial growth on Jensen agar media after processing. As the media was devoid of nitrogen source, it only enabled selection of the nitrogen fixing bacteria, and the count was 53. The isolates were subsequently tested for other plant growth promoting attributes under a stress of 200 mM salinity in laboratory conditions that include (i) N_2 fixation by Kjeldahl method, (ii) phosphate solubilization by Molybdenum blue method [5] in NBRIP (National Botanical Research Institute's Phosphate) broth, (iii) Indole acetic acid (IAA) production [4] in Yeast extract mannitol media, and (iv) Siderophore producing ability by universal chrome azurol S (CAS) method [11].

The hemolytic activity of the selected PGPR on sheep blood agar was performed to ascertain it's safe use if entered in the human food chain [2]. To observe the growth pattern of the isolates under both normal

and saline conditions, culture was grown in batch system employing varied salinity under control (0%) and the test conditions (0.63%, 1.25%, 2.5%, 5%, 7.5%, 10% and 15%) in nutrient broth with the initial inoculum of 10^9 CFU ml^{-1}. The absorbance of the growing culture was measured spectrophotometrically at 600 nm in every two-hour intervals.

To understand the ability of the selected PGPR as biofertilizer to support the growth of a salt-sensitive rice cultivar, *Oryza sativa* BR 28 under normal and stress conditions; pot experiments were conducted under controlled environment. Mass production of the PGPR, and a bacterial strain, *E. coli* DH5α to be used as control was performed in Yeast extract mannitol broth (YEM). Biofertilizer was formulated aseptically according to the Bureau of Indian Standards (BIS) guidelines [3]. Prepared biofertilizer was uniformly mixed with soil and watered. Duplicate earthen pots for each test condition (PGPR, control- *E. coli* DH5α and uninoculated) were employed. The seeds were placed on filter paper, incubated at 56°C for 24 hours followed by soaking with tap water for 2 to 3 days. Then around 2L hydroponic solution was taken in the plastic tray and germinating seeds were left floating on the solution via cock sheet as a supporting material. After 12 days of cultivation in hydroponic solution, plants were transferred into earthen pot. Length of root, stem, and leaves were measured for each plant. After 45 days of rice cultivation under regular condition, a stress of 200 mM salinity was applied to plants where applicable [8]. Then after 25 days of salt application, length of stem and leaf were determined, and the pool of mRNA was extracted from plant tissues (root and stem).

For estimating IAA, total carbohydrate, chlorophyll, protein, proline and malondialdehyde (MDA) in the cultivated rice plants, 0.1 g leaf $stem^{-1}$ plant tissue sample was taken each time to follow the method described in [4], [7], [10], [6], [1] and [9], respectively.

Transcriptomic analysis of plants' salt responsive genes namely, *NHX1*, *GIG* and *BZ8* [8] was performed to observe their changes in the modulation of expession upon addition of PGPR. 30 mg of plant tissue (root and stem) was processed for mRNA extraction using GSure™ Ultra Nucleic Acid Isolation Kit (GCC biotech, India), which were eventually reverse transcribed into cDNA by using ImProm-II™ Reverse Transcription System (Promega, USA). cDNAs were then used as templates to compare the expression of genes in biofertilizer-applied and control plants. The amplified products were electrophoresed on 1% agarose gel and the images were captured using gel Doc (AlphaImager, USA).

Results

Among the 53 bacterial isolates, the isolate that exhibited profound plant growth-promoting activities under 200 mM salinity, was identified as *Bacillus aryabhattai*, hereafter *B. aryabhattai* MS3. Identification was based on its biochemical characterization, sequence analysis of 16S rDNA followed by its phylogenetic and molecular evolutionary analyses by blasting the sequence on NCBI. Sequence data was deposited to GenBank, and the assigned accession number was MG209571.

The dynamic growth pattern of MS3 in batch culture in presence of 200 mM salt revealed that growth curve of MS3 exhibited longer lag phage under stress when compared to normal state (no added salt); however, it rapidly matched with the later with similar growth rate indicating higher tolerance against salt stress.

The plant growth promoting (PGP) properties of MS3 under *in vitro* laboratory condition showed comparable PGP attributes when grown under normal and saline conditions. The abilities were recorded for nitrogen fixation (11 and 7%), IAA production (35 and 25 μg mL^{-1}), phosphate solubilization (3.0 and 2.4 μg μL^{-1}) and siderophore release (70% and 20% unit) respectively. The isolate added in soil in the form of biofertilizer to support growth of a salt-sensitive rice cultivar under non-saline condition demonstrated no significant difference in between biofertilizer-added and control pots. The scenario, however was statistically significant when plants were challenged with 200 mM salts added after 45 days of cultivation that produced 46% and 8% survival rates respectively, estimated after 25 days of salt application.

Plants fundamentally cope with the unfavorable effects of elevated salinity stress by different metabolic changes. Plant hormones control plant growth and play role in adaptation to various stresses. The endogenous content of plant hormones in leaf and stem tissues of MS3 applied rice plants was found higher compared to uninoculated plant tissues. The IAA in stem and leaf tissues of inoculated rice was 5.3 and 7.8 μg g^{-1} as compared with control (uninoculated) plants (3.7 and 4.5 μg g^{-1}) under 200 mM NaCl. Similar trend was also reflected in chlorophyll content in leaf and stem tissues of MS3 inoculated rice (1.3 and 1.9 μg g^{-1}) versus uninoculated (0.1 and 0.4 μg g^{-1}). Proline, a compatible solute thought to provide salt-tolerance gives a positive correlation for tolerance. Its content was found higher (189 μM g^{-1}) in MS3-inoculated compared to uninoculated control rice plants (170 μM g^{-1}) under salinity stress condi-

tion. Conversely, Lipid peroxidation of cell membrane is increased under prolong exposure to stress. The amount of MDA produced because of lipid peroxidation in rice was lowest (5 μM g^{-1}) in MS3-inoculated plants as opposed to uninoculated plants (12 μM g^{-1}) under salinity condition.

To address the molecular nature of acquisition of salt tolerance in plants, the semi-quantitative reverse transcription-PCR (SQRT-PCR) was conducted extracting total mRNAs of plants followed by converting them into cDNA, to be used as templates only to analyze transcriptomic distribution of three salt-tolerant genes in plants: *NHX1, GIG* and *BZ8*. While under normal condition, the expression of all three genes were evident, the bacterium selectively up-regulated the expression of *NHX1* gene only under salinity, a situation not evident in controls (Figure), therefore is thought to confer salt-tolerance to plants.

Discussion

We are moving to a post-carbon era, where climate change mitigation and adaptation are combined with other goals to build a sustainable future. This ties in closely with the United Nations' Sustainable Development Goals. The strain *B. aryabhattai* MS3 demonstrated phenomenal adaptation at elevated salt concentrations, still delivering plant-growth promoting attributes through plant-microbe interaction. As the study suggests, they aided plants by increasing availability of nutrients (P, Fe), accelerating IAA and chlorophyll production, enhancing proline accumulation, and decreasing malondialdehyde formation; the cumulation of which resulted in survivability of plants under salinity stress compared to the control condition. Further, the upregulation of sodium proton antiporter (*NHX1)* gene, which express a plant vacuole membrane protein responsible for catalyzing uptakes of Na^+ from cytosol into the plant vacuole in exchange of H^+ under higher salt concentration could advocate for tolerance. Entrepreneurship for constructing bio-bank composed of such potential PGPR could be a way forward for climate-change preparedness program for its effective application as biofertilizer for sustainable agriculture and food security under changing climate conditions.

Conclusion

The novel salt-tolerant strain, *Bacillus aryabhattai* MS3 has the potential to support plant survivability under salinity stress in the form of bio-fertilizer by modulating salt-tolerant gene expression, and providing vital plant-growth promoting activities to plants.

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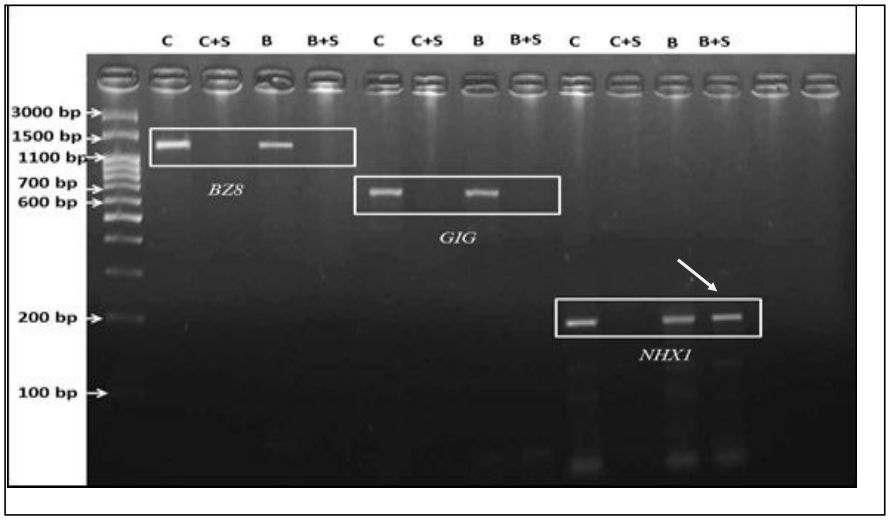

Figure. SQRT-PCR of NHX1, GIG and BZ8 plant genes, electrophoresed on 1% agarose gel. Plants either bio-fertilized (B) with MS3, or not under normal (C), or salt-stressed (S) conditions were treated for analyses. Specific expression of NHX1 is indicated by arrowhead in bio-fertilized plants under salinity. Marker used was 100 bp-3 kb DNA ladder

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EFFECTS OF LONG-TERM FERTILIZATION ON STRONTIUM (SR) AND VANADIUM (V) IN AGRICULTURAL SOILS OF PRIMORYE IN RUSSIA UNDER CLIMATE CHANGE

Yuliya A. Kosheleva*, Yana O. Timofeeva
Federal Scientific Center of the East Asia Terrestrial Biodiversity FEB RAS, Vladivostok, Russia
Email: yuliyashoo@yandex.ru (*corresponding author)

Strontium (Sr) and Vanadium (V) are potentially dangerous for the natural environment. Little is known about the accumulation and mobility thought soils profiles of different Sr and V forms. Several studies of Sr and V distribution in soils have demonstrated strongly fixation of elements by different soil properties. Climate change and, respectively, soils redox cycles changes can affect the main soil properties and of their associated elements. In current work, contents and the main factors controlling the vertical distribution and accumulation of total, "pseudo-total" and water soluble forms of Sr and V in the agricultural soils formed under long-term fertilizer application were studied. Total Sr and V contents increased to 10% and 2% respectively with adding fertilizer. The contents of "pseudo-total" Sr and V forms increased to 20%. The concentrations of water soluble Sr and V forms increased to 65%. The contents of Sr and V were manly controlled by soil acidity levels and organic C content in studied soils. Additionally, Sr was associated with Ca-, P-, Mn-containing compounds and V with Al-, Si-, Fe- containing compounds. Knowledge of the chemical behavior of the Sr and V in the agricultural soils creates a scientific basis for risk assessment and remediation strategies.

Keywords: *agricultural soils; fertilizer application; strontium; vanadium; soil properties, climate change.*

Introduction

One of the most important scientific and practical problems is the stability of the soil to excessive heavy metals input. Extensive areas of land are contaminated with heavy metals [15, 21]. The content, distribution and accumulation such heavy metals as Zn, Pb, Ni, Cd, Cr and Cu were studied in detail in soils of different regions of the Russian Federation. At the same time, attention to such elements as Sr and V is not enough to have a real understanding of the background content of these elements in soils. The features of the interaction of elements with the basic soil properties and migration of Sr and V in soil-plant system are poorly studied. Strontium and V are potentially dangerous for the natural environment [21]. The toxic Sr level for biota has not been completely established because of insufficient evidence about deleterious effects on biota of the high levels of stable Sr in the biosphere. Strontium has a similar action to Ca and Sr plays a similar role in many cellular metabolic possesses [2, 8]. Concentration of V above 2 ppm (for some bush beans above 13 ppm) in plants and above 140 ppm in the soil solution is toxic for the plants as high concentrations of V causes chlorosis and growth limit [7, 8].

Based on published data, in agricultural soils of Sweden and Japan the average concentration of V is 69 and 180 mg kg^{-1}, respectively, Sr is 163 and 190 mg kg^{-1}, respectively [8]. One of the most common sources of input of the studied elements is the use of phosphorus fertilizers in the arable soil. The content of Sr and V varies from 25 to 500 mg kg^{-1} and from 2 to 180 mg kg^{-1}, in phosphate rock, superphosphate, ammophos and other phosphorus-containing fertilizers, respectively [8, 9]. At present time there are no regulatory documents that determine the permissible content of Sr and V in fertilizers on the territory of the Russian Federation. On the Primorsky Krai territory there is a state development program and the area of land used in the agricultural production of the region is increased. At the same time, the amount of fertilizers adding in this area is not controlled and causes a change in the elemental composition of the soil [14].

The aim of the current work was to assess the influence of long-term mineral and organo- mineral fertilizers application on the content of different Sr and V forms in arable soils of Primorsky Krai.

Materials and methods

The objects of this study were soils formed in the territory of agrochemical station of Primorye Research Institute of Agriculture Far Eastern Branch of Russian Academy of Sciences. The experience of applying different types of fertilizers has been carried out for 77 years. The investigated type of soil is

characterized by high content of humus (to 4%) and clay and silt particles (80–85%). Soils are formed on lake-alluvial deposits. These soils occupy more than 50% of agricultural land of Primorsky Krai [4].

8 full rotations of 9-full crop rotation had been completed by the time of the research. During this time, $N_{2020}P_{3385}K_{2465}$ adding as part of mineral fertilizers, 320 t ha^{-1} of manure and 41.6 t ha^{-1} of lime. Applied fertilizer amount was calculated with replacement of cultures. In period from 2000 to 2009, additional experience was carried out with higher (from 3 to 5 times) doses of fertilizers and different methods of soil treatment [5].

The experiment was carried out in the field on plots in 3-fold repetition, with each of which a mixed soil sample was taken to the depth of the arable horizon (n=18). The plot area is 150 m^2. The experimental variants selected – without fertilizer (control), with the adding of mineral (NPK) and organo-mineral fertilizers (PK+manure+lime).

Analysis of soil samples was carried out at the center for collective use of Biotechnology and Gene Engineering of the FSC Biodiversity FEB RAS. Total SiO_2, Al_2O_3, Fe_2O_3, MnO, P_2O_5, CaO, Sr and V contents were determined via energy dispersive X-ray fluorescence spectroscopy (EDX) using a Shimadzu EDX- 800HS-P instrument (Shimadzu EUROPA GmbH) equipped with a rhodium X-ray tube (settings: vacuum, voltage 50 kV, current 100 mA, detection time 300 s, dead time 20%, and a collimator of 10 mm). Data were analyzed using PCEDX Shimadzu software. The elements were measured by K-line emission. Eight certified reference standard soil samples. Validation of calibration curves constructed for elements present in the standards was performed through analysis of standard reference materials. One standard soil sample (2499–83) was included for every five unknown samples.

The Sr and V potentially plant-available forms extracted with a mixture of fluoric and nitric acids according to the methods described by Pansu M. and Gautheyrou J., named "pseudototal", according to research by Nesterova et al. [10, 11]. Water-soluble forms of elements were extracted with water extraction (soil : water – 1 : 10) [16]. The elements concentration in acidic and water extracts was measured using the atomic absorption spectrometry method, on the AA-7000, Shimadzu atomic absorption spectrophotometer.

The humus content was determined by the method of Tyurin [17]. The soil acidity was determined by potentiometric method in accordance with the standard recommendations [6].

Strontium and V concentrations in the studied samples compared with the established mean concentrations of elements in the surface horizons of the European soils, agricultural soils of Japan and soils of the world [8].

Results and discussion

The average abundance of total Sr in the soils of different variants of the experiment was as follows: organo-mineral fertilizers > mineral fertilizers > control. Pseudototal and water-soluble forms of Sr and all study forms V have same distribution range: fertilizer > organic fertilizer > control.

Comparison of the Sr and V content in the studied soils with relevant literature data about mean values of elements in soils of Japan, Europe and the world indicates the presence of some excess of the established values. The concentration of total Sr forms was below the average content of this element in the soils of Japan and in the soils of the world and higher than the average level of the element content in the soils of Europe. Total V in the studied soils was 1.5 times higher than the average content of this element in the soils of Europe. In the soils of the control variants of the experiment, the concentration of total forms of Sr varied from 143 to 151 mg kg^{-1}. According to Kabata-Pendias, the Sr content in the agricultural soils of Japan varied from 32 to 130 mg kg^{-1}; in the arable soils of Sweden from 112 to 258 mg kg^{-1} [8]. The total Sr in the soils increased by 10%, the content of pseudototal and water-soluble forms Sr increased by 20% and 70%, respectively, when adding fertilizers. The content of total V in the control varied from 96 to 107 mg kg^{-1}. Arable soils of Sweden are characterized by a V content ranging from 28 to 111 mg kg^{-1}; in the agricultural soils of Japan it varied from 94 to 250 mg kg^{-1}. Adding of organo-mineral and mineral fertilizers did not significantly increase of the total V content in the soils (up to 2%). The increase of the concentration of water-soluble and pseudototal forms V were at 75% and 19%, respectively [8] (Table 1).

Total Sr largely dependent on the soil acidity and Ca–, P–, Mn– content in the soils of the control variants and this correlation increased by applying mineral and organo-mineral fertilizers. Pseudototal Sr significantly correlated with the humus content and Al–, Fe–, Si– containing phases. Significant correlations observed between concentration of water-soluble forms Sr and Al–, Fe–, Si– content in the control variants. The distribution and accumulation of water-soluble forms Sr controlled by soil acidity with adding of organo-mineral fertilizers. The mineral fertilizers adding increased the relationship between total Sr– and Si– content. Pseudototal forms Sr find

Table 1

The content of Sr and V different forms in soils, studied experience variants (mg kg^{-1})

	Total forms		Pseudototal forms		Water soluble forms	
	Sr	V	Sr	V	Sr	V
Control experience variaints	146.80	102.63	87.09	69.94	0.02400	0.00075
Organo-mineral fertilizers adding	161.83	104.18	105.61	80.14	0.07150	0.00145
Mineral fertilizers adding	153.22	104.62	107.68	85.90	0.07600	0.00295
World-soil average	175	129	-	-	-	-
Agricultural soils of Japan	190	180	-	-	-	-
Top soils of Europe	130	68	-	-	-	-

Table 2

The correlation coefficients between the contents of Sr and the physical-chemical properties of soils

	Total Sr			Pseudototal Sr			Water soluble Sr		
	Control	Organo-mineral fertilizers adding	Mineral fertilizers adding	Control	Organo-mineral fertilizers adding	Mineral fertilizers adding	Control	Organo-mineral fertilizers adding	Mineral fertilizers adding
Al_2O_3	–0.82	–0.91	–0.98	0.95	0.22	0.86	0.50	–1.00	0.87
SiO_2	–0.82	–0.93	1.00	–0.95	–0.22	0.31	–0.50	1.00	0.98
P_2O_5	0.82	0.92	0.87	0.65	–0.33	0.09	0.87	–0.80	0.92
CaO	0.82	0.92	0.84	0.66	–0.28	–0.28	0.86	–0.83	–0.97
MnO	0.82	0.91	0.93	–0.66	0.30	–0.71	–0.87	0.82	–0.96
Fe_2O_3	–0.84	–0.93	–0.98	–0.66	0.30	–0.75	–0.87	0.82	–0.95
Humus	–1.00	–0.99	–0.72	–0.66	0.32	0.10	–0.87	0.80	–0.82
pH KCl	1.00	0.99	–1.00	0.68	–0.27	0.09	0.85	–0.84	0.91

a significant correlation with the humus content. The distribution and accumulation of water-soluble forms of Sr controlled by the humus and Al–, Fe– content, and the soil acidity (Table 2).

The Sr– content in soils is often associated with calcium and phosphorus because of the similarity of geochemical characteristics, and it concentrated in Mn–containing minerals under natural environmental conditions [8]. The main part of Sr pseudototal forms was incorporated to the organic-mineral soil complex and mineral phase of soils. Most of the previous studies have demonstrated that Sr is strongly fixed by organic matter in soils [8]. However, a recent study has shown that Sr formed non-stable complexes with organic matter and that in acid soils, Sr transported by the soil solution throughout the soil profile [3]. The results obtained from the soils of the control variants of the experiment do not confirm this trend. The absence of a significant relationship between the content of Sr water-soluble forms and the humus content in soils of the control variants indicated a strong fixation of the element with organic matter of the soil. Additional doses of Sr in the variants of experiment with the application of organo-mineral fertilizers accompanied by the formation of easily mobile Sr compounds with Ca–, P–, Mn– containing phases and the element is actively transferred to the soil solution. Strontium sorbed on the surface of Al and Fe compounds as part

Table 3

The correlation coefficients between the contents of V and the physical-chemical properties of soils

	Total V			Pseudototal V			Water soluble V		
	Control	Organo-mineral fertilizers adding	Mineral fertilizers adding	Control	Organo-mineral fertilizers adding	Mineral fertilizers adding	Control	Organo-mineral fertilizers adding	Mineral fertilizers adding
Al_2O_3	–0.60	0.86	–0.12	–0.74	–0.52	0.98	–0.50	1.00	0.87
SiO_2	–0.60	0.89	–0.07	0.74	0.52	0.87	0.50	–1.00	0.33
P_2O_5	0.60	–0.88	–0.55	–0.98	0.01	0.74	0.01	0.80	0.11
CaO	0.60	–0.88	–0.59	–0.98	–0.04	–0.85	0.00	0.83	–0.29
MnO	0.60	–0.87	0.31	0.98	0.02	–1.00	0.00	–0.82	–0.72
Fe_2O_3	–0.57	0.89	–0.12	0.98	0.02	–1.00	0.00	–0.82	–0.75
Humus	–0.12	1.00	0.73	0.98	–0.01	–0.59	0.00	–0.81	0.09
pH KCl	0.12	–1.00	0.11	–0.97	–0.05	0.74	–0.03	0.84	0.11

of soluble complexes and migrates beyond the soil profile when applying mineral fertilizers [1, 18].

The distribution and accumulation of total and pseudototal forms of V controlled by the content of Ca–, P–, Mn– phases in the control variants soils of experience. Additionally, the contents of V pseudototal forms controlled by the soil acidity. Water-soluble forms V have a low level of correlation with the soil acidity. The distribution and accumulation of total and water soluble forms of V controlled by the humus and Fe–, Al–, and Si– content by fertilizers adding. Concentration of the V pseudototal forms correlated with the soil acidity (Table 3).

Numerous studies indicated that V fixed in the composition of poorly soluble complexes with polyvalent cations, such as bivalent calcium [19]. Additional intake of V with fertilizers leads to active fixation of the element in the organic-mineral soil complex and soil minerals containing Fe and Al, but this relationship is not strong and the element easily migrated into the soil solution. According to van der Weijden and van der Weijden [20], V in soils is frequently co-associated with Fe [12, 13, 20]. Water-soluble forms are compounds available to plants, easily migrating along the soil profile. The most mobile form of V in soils is VO^{2+}, which prevails in acidic soils and forms stable complexes with soil organic matter. Anionic forms of this metal are VO^{3-}, VO_4^{2-} and H_2VO^{4-} more often prevail under neutral and alkaline conditions of soil solution [8, 13].

Conclusions

With long-term fertilization, the content of total forms of Sr increased by 10%; pseudototal forms Sr by 20%; water soluble forms of Sr 70%, in comparison with the control variants. When additional doses of Sr in the composition of fertilizers added, the level of the element's relationship with Ca–, P–, Mn– and Si–containing phases increased. When applying mineral fertilizers, the main sources of water-soluble Sr compounds are Al and Fe-containing compounds and humus.

A significant increase in the concentration of total forms of V when fertilizer was not installed, however, the content of water-soluble and pseudototal forms of V increased by 75% and 19%, respectively. In soils of the control variants of the experiment, the V concentration controlled by Ca–, P–, Mn – content. The additional input of V with fertilizers leads to the element fixation in the composition of the organic-mineral soil complex and in the composition of soil minerals, where the V predominant forms are pseudototal and water soluble forms.

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AMMONIA-OXIDIZING BACTERIA RESPOND TO MULTIFACTORIAL GLOBAL CHANGE

Marina L. Sidorenko
Federal Scientific Center of the East Asia Terrestrial Biodiversity FEB RAS, Vladivostok, Russia
Email: sidorenko@biosoil.ru

In many recent studies, the effects of climate change on the future of biodiversity have been studied. As a result of human economic activity, extraction of mineral resources, land-use management, application of fertilizers (for example, nitrogen-containing compounds), carbon dioxide emissions into the Earth's atmosphere increase. This causes a change in the air temperature in the direction of increase and a change in the quantity and quality of the sediments, causing a wetting of the soils. The reaction of bacteria capable of oxidizing ammonia, belong to the group of chemo-litho-autotrophic microorganisms and at the same time are not associative microflora, was studied. In both natural and human-induced disturbance altered ecosystems, they strongly depend on these bacteria through intensive oxidation of ammonium. In response to artificially created climate changes, we received a change in the structure of the ammonium-oxidizing bacteria (AOB) community. The addition of a large amount of nitrogen fertilizer has led to a change in the number of bacteria that oxidize ammonia, while the temperature and humidity levels have changed, which also have an impact on AOB. In response to the increase in carbon dioxide significantly reduced the number of AOB. If, in this case, the amount of precipitation also increased, then this decrease was most pronounced. Increased nitrification caused also caused changes in the composition of the community of microorganisms. These results show that microbial communities can be successively changed by climate change and that these changes may have consequences for the functioning of the ecosystem.

Keywords: *ammonia-oxidizing bacteria, agricultural soil, climate change.*

Introduction

Environmental systems are changing globally under the pressure of human activity. As a result of some studies it has been shown that numerous joint multifactorial changes can affect the diversity, quantity and functionality of microbial communities. The interrelation of such changes is seen through the increase in the amount of released atmospheric carbon dioxide due to the extraction and combustion of various fuels and combustible materials, as well as the intensification of land use. As a result of such a person's activity, the amount and quality of precipitation, temperature changes, soil-formation process changes occur, including intensive transformation of nitrogen in soils. Soil microorganisms play an unimportant role in the internal processes and actively respond to global changes. Almost nothing is known about the effect of multifactorial changes on communities of microorganisms in soils.

Bacteria capable of oxidizing ammonia belong to the group of chemo-litho-autotrophic microorganisms and, at the same time, not being an associative microflora. Both in natural and anthropogenically altered ecosystems they are strongly influenced by these bacteria through intensive oxidation of ammonium [11]. This group of bacteria is not chosen by chance. Most studies consider it an ideal model for studying the ecology of microorganisms for a number of reasons [8]. First, these bacteria are widespread in nature, they can be found in soil, fresh and sea water. Secondly, they have great ecological significance, namely: these bacteria play a central role in the nitrogen cycle, because they carry out the limiting stage of nitrification – the oxidation of ammonia. Third, the activity of the enzymes of ammonium-oxidizing bacteria participating in nitrification processes can be changed by changing the environment [10, 16]. Finally, all ammonium-oxidizing bacteria carry the amoA gene; it is a protein that catalyzes the oxidation stage of ammonia to hydroxylamine, which codes for the α-subdeitenium of the enzyme-ammonia-mono-oxygenase. This gene is widely distributed among the ammonium oxidizing bacteria and is used as a molecular marker that allows detecting them and to count without the laboratory culture. Most soil bacteria are not suitable for cultivation in the laboratory, so it is very important to use such molecular markers as a known unique gene for a more accurate assessment of the diversity and quantity of microorganisms in the soil [4]. The object of the current study was bacteria capable of oxidizing ammonia, affected by various environmental changes.

Materials and Methods

In current work, various environmental changes that can affect the ecosystem in soils were created artificially. Namely: 1) simulation of increasing atmospheric CO_2 (adding carbon dioxide to the air with a target concentration of 700 ppm); 2) imitation of precipitation (increased (by 50%) moistening of the soil); 3) imitation of global warming (increase in ambient temperature); 4) increased nitrogen content (by adding Ca (NO_3) 2 in an amount of 7 g m^{-2}). The reaction of ammonium-oxidizing bacteria (AOB) on these factors was studied both individually and in a complex. Separately, carbon dioxide amount in the airspace was studied, in experiments with simulated precipitation, temperature increase and nitrogen addition.

Results and Discussion

As a result, in response to these man-made changes in the soil ecosystem, some influences the community structure of AOBs were recorded, namely: change in the number of these bacteria. In response to the addition of a nitrogen-containing fertilizer, the number of bacteria that oxidized ammonia increased significantly, on 74.4%. Ammonia oxidizer populations are influenced by temperature. There was also an increase in the AOBs number with increasing ambient temperature, on 51.2%. With the increase in atmospheric air of carbon dioxide, a decrease in the AOBs total number, on 18.6%. The most pronounced decrease in the amount of AOB (on 30.2%) was observed in response to an increase in soil humidity. The complex impact of these factors adversely affected the AOB community, their number was decreasing on 25.6%.

The changes in the AOBs amount observed in response to artificially created changes may well be the result of the indirect influence exerted by the common microbial community. Literature review illustrates, the amount of AOB can vary under the form of humidity in the soil, since in the dock of their members, it also goes down. An increase in the number of members of the investigated group of microorganisms can occur with a relatively moderate increase in humidity, by reducing water stress [1, 5]. A significant reduction in the number of AOB occurs with a strong increase in humidity, due to a decrease in the diffusion of oxygen into the soil [1]. Therefore, in order to achieve a balance between these two effects, it is necessary to maintain optimum soil humidity. This balance can underlie the interaction that was observed in the study of a set of factors. Since the increase in humidity results in a sustained negative impact on the AOB community, due to the reduced availability of oxygen, it is likely that an increase in temperature can reduce water stress and thereby increase the access of oxygen to the soil.

The effect of carbon dioxide can also be indirectly through soil humidity. Carbon dioxide increases soil humidity due to changes in the activity of the general microbial community of the soil. The same reaction of the investigated group of bacteria on the increased soil humidity and carbon dioxide is found in current research. As the carbon dioxide content increases, the rate of competition for nutrient resources between AOB and heterotrophic microorganisms in the soil changes. The increased level of carbon dioxide increases the content and activity of heterotrophic microorganisms in the soil [7, 9]. AOBs are the lowest competitors for some resources (for example, oxygen) for heterotrophic microorganisms, and increased competition of resources can lead to an increase in CO_2 content due to a decrease in the number of AOBs [1]. The number of the investigated group of bacteria can significantly decrease with a simultaneous increase in the amount of precipitation, as these results in the elution of mobile nutrients and a decrease in the diffusion of oxygen.

Experimental data have been obtained in favor of this conclusion. Thus, increased humidity and precipitation contribute to an increase in the carbon dioxide content in the surrounding atmosphere by a factor of 2. This probably serves as a key factor to a decrease in the AOBs number in a multifactor test. When nitrogen was introduced into the soil, a change in the amount of AOB was observed, which, very likely, was mediated by the entire action of the nitrate on the soil. So, Anna Hermansson and Per-Eric Lindgren [6] point out that in the fertilized soil ammonia-oxidizing bacteria three times more than the number of bacteria in the unfertilized soil. Some researchers point out that the availability of nitrogen can decrease with a high amount of precipitation, because the losses of available nitrogen increase. A significant role in this process is played by an increased temperature, which leads to an increase in soil humidity.

The results obtained show that global multifactorial changes can consistently change microbial communities. Such changes in the microbial community can have serious consequences and disrupt the functioning of the entire system. Free living prokaryotes, to which the group of bacteria we are researching, are key participants in the functioning of ecosystems and represent a large part of the Earth biodiversity [14]. The change in microbial diversity, its abundance, can lead to a disruption in the pace and functions throughout the system. Due to the low degree of functionality, microorganisms of the nitrogen cycle and, in particu-

lar, AOB [15] are particularly vulnerable to this. Literature review shows, there are indications of a connection between the functions of denitrifying bacteria and the structure of the community [2, 3, 12].

Conclusion

An answer was received to the multifactorial global changes from the communities of free-living soil ammonium-oxidizing bacteria. A significant quantitative change in the structure of the community of these bacteria was demonstrated. The number of AOBs varied with temperature, precipitation, carbon dioxide and nitrates. The data obtained agree with the literature review, which indicate that the water balance of soils often causes global changes in ecological communities [13]. Some AOB reactions that do not carry global changes can be representative predecessors in the modeling of global changes. The insignificant but notable known reactions of these bacteria can predict the response to much more serious changes in the system. For example, the AOB reaction for the addition of nitrogen was similar to the previously studied effect of agricultural fertilizers [4]. Some changes in the community of ammonium-oxidizing bacteria observed are important for understanding possible changes in the functioning of the ecosystem. This point to the potential importance of feedback between such factors of the soil ecosystem as humidity, carbon dioxide, nitrogen, temperature and microbial groups involved in nitrogen transformations (for example, nitrogen fixing, denitrification and nitrite microorganisms). Current study shows that a full awareness of the environmental consequences of a global change requires an understanding of the response of the microbial community as one of the fastest-changing factors.

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LAND RECLAMATION AND TRANSFORMATION OF FLOODPLAIN-CHANNEL COMPLEXES AT THE MIDDLE AMUR LOWLAND

Andrey V. Anoshkin*, Vitaliy A. Zubarev
Institute for Complex Analysis of Regional Problems Far Eastern Branch
Russian Academy of Sciences (ICARP FEB RAS), Birobidzhan, Russia
Email: anoshkin_andrey@rambler.ru (*corresponding author)

Due to the specifics of climate, geology and relief of the Russian Far East, extensive land reclamation has been carried out in this region for more than sixty years in order to create the necessary conditions for agricultural production. The purpose of this land reclamation is heavy soils drainage in Primorye and the Amur Region. An extensive network of reclamation systems of open and closed types was created. This paper presents the results of studying the effect of land reclamation on floodplain-channel complexes (FCC) of the Middle Amur Lowland. It was found that construction and subsequent operation of reclamation systems (water receivers, main canals, regulating dehumidifiers) led to general degradation of FCC with full cessation in development of channel and riverine forms at micro- and meso- relief, and their complete silting. The concentration and seasonal dynamics of heavy metals in the soils of meliorated lands, in bottom sediments and water of small rivers and main canals at FCC was estimated. The content of heavy metals in the soils of meliorated lands' decreased in comparison with unaffected environment. At the same time, accumulation of heavy metals took place in the waters and bottom sediments of main canals and water receivers. In addition, the paper presents data on the impact of catastrophic and unfavorable hydrological phenomena (floods, freshets) on the dynamics and state of agrocenoses within the boundaries of FCC.

***Keywords**: floodplain-channel complex, land reclamation, heavy metals, Middle Amur Lowland.*

Introduction

Specific features of natural conditions at the Middle Amur Lowland have determined intensive processes of swamping and over-moistening [1, 4, 8]. Land reclamation has been carried out in this region for more than sixty years in order to create the necessary conditions for agricultural production. A significant part of river basins at the Middle Amur Lowland has been transformed to varying degrees by the reclamation network. The land reclamation systems are represented by water receivers, main canals and drainage grooves. Water receivers are natural watercourses, mainly rivers; less often they are depressions in the relief that do not have a runoff.

Land reclamation as a complex of organizational, economic and technical measures has been widely developed within floodplain-channel complexes (FCC) of the Middle Amur Lowland [5]. FCC is very dynamic and, at the same time, vulnerable natural system that consists of river channels and floodplains as main elements [3]. Man-made impact on some parts of floodplain or riverbed causes a whole chain of processes that substantially alter the components of these geosystems. The purpose of the current study is to assess the effect of land reclamation on the state and dynamics of floodplain-channel complexes at the Middle Amur Lowland.

Historical Reference

The development of land reclamation in the Middle Amur Lowland dates back to the beginning of the 20th century. Studies conducted in 1926 showed that the vast majority of swamped areas could be used for agricultural purposes only after land reclamation. The construction of reclamation channels was carried out with the help of "Sudanese ditch digger", graders and manual rework. Steam coal operating excavators were used in the construction of canals with a depth of more than 1.5 m. At that time there was one excavator station in Birobidzhan, in which there were 10-15 excavators. By 1938, 5 reclamation systems had been completely drained and commissioned for settlers.

In the early 50-ies of the XX century reclamation stations began to be founded. All expenses for research and design of land reclamation work were covered by the state budget.

Along with construction reclamation divisions, repair and maintenance water management organizations were founded and developed. By 1980, the land reclamation department had a network of repair organizations and production facilities throughout the Middle Amur Lowland. Land reclamation continued in the 70s of XX century at the highest rates. By the mid 80s, the technology of land reclamation included the trenchless laying of polyethylene pipes, with the

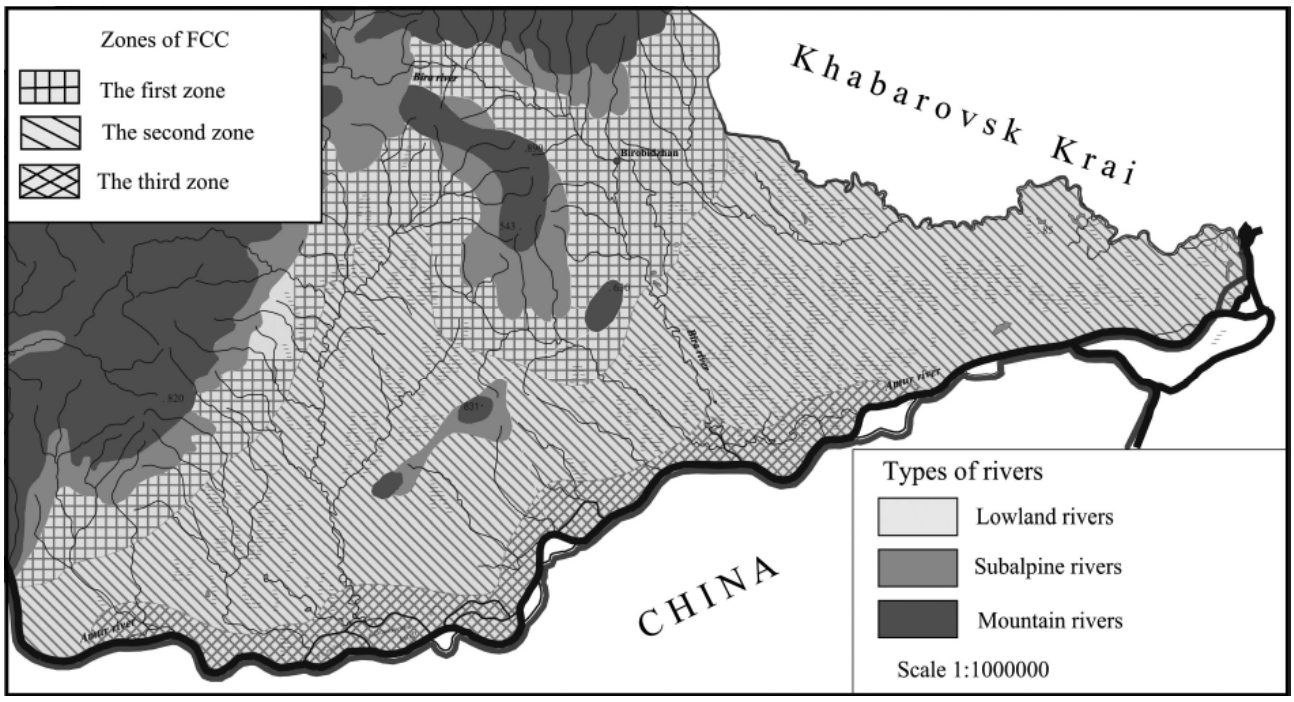

Figure. Zones with characteristic types of FCC at the Middle Amur Lowland [2, 9]

help of which more than 1000 km of drainage channels were laid.

Thus, reclamation measures significantly increased the efficiency of agricultural production in the territory of the Middle Amur Lowland and reducing its dependence on weather conditions. On the other hand, these measures led to the transformation of natural floodplain-channel complexes and determined new vectors for their development and dynamics.

Characteristics of the study area

Most rivers of the Middle Amur Lowland have a length of more than 30 km, characterized by small inclines with an average altitude difference of 45-50 m. The main river flow is directed from the northwest to the southeast. The overall pattern of the river network is feather-like with sections of radial rivers in areas of rock pillars. The river valleys are poorly expressed in the relief, the watersheds are indistinct and the catchments are waterlogged on vast areas.

The study area has monsoon climate of temperate latitudes, largely determined by the annual cycle of changes in the temperature gradient between the ocean and the continent, the prevailing wind direction and the pronounced annual maximum precipitation in summer months. The average annual precipitation is about 600 mm; about 10% of the total amount precipitates in winter and up to 90% – during a warm period [6].

The river water supply is mostly pluvial, accounting for up to 70% of the runoff. The following phases of hydrological regime are identified: spring flood, summer and autumn freshet and winter low water; summer low water usually does not occur.

The formation of spring floods is due to winter snow and precipitation in the form of rain and wet snow. The duration of spring floods is up to 15 days on small rivers and up to 30 days on large and medium rivers.

The second most significant phase of water regime of rivers in the study area is rain floods – single or multi-peak water increase, separated by periods with relatively low levels lasting up to 10 days. The average amount of runoff during the flooding period exceeds 60% of its annual values.

Winter low water is the longest and at the same time low-water phase of the water regime. It is usually observed from November, the moment of freeze-up formation, till April. During this period, small rivers freeze to the bottom, medium and large rivers are characterized by a stable level and a minimum runoff during the year. Debacle occurs almost simultaneously throughout the lowland at the end of the second – the beginning of the third decade of April.

Due to natural conditions, morphodynamic types of river beds and geomorphological types of floodplains, three zones with characteristic types of FCC are detected [2, 9] (Figure).

The first zone is FCC of rectilinear channels of the foothills with predominance of bilateral marshy floodplain composed of pebble-sandy alluvium and

distributed fragmentarily, which is characteristic for fairly large rivers (tributaries of the Amur River). Their valleys are box-shaped and are well expressed in relief. Their bottoms are flat and swampy, while the sides are flat and have soft outlines. The mean river fall is 25-60 m per 30 km. Floodplain is swampy and has meadow nature. Sandy and sandy-pebbly soils predominate; loamy, clayey and peat deposits prevail in depressions.

The second zone is FCC of meandering channels with sandy alluvium, developing in loose rocks and with predominantly segmental bar plain. It occupies most of the Middle Amur Lowland. The valleys are poorly expressed in the relief. The watersheds rise above the surrounding territory by 6-8 m, maximum by 12 m. Leveled surfaces with small differences in altitude predominate in river valleys. Elements of river valleys are poorly differentiated, except for FCC. The significant part of river basin is swamped or waterlogged. Mean river fall is 12-15 m per 60-80 km; riverbeds tend to meander. A low floodplain with lot lakes, dry channels of temporary streams and erosion gullies is well expressed.

The third zone is floodplain-channel complexes of braided, spreading channels, composed of fine- and medium-grained sandy alluvium, that develop in loose sediments. These complexes are characterized by a bar-island floodplain. They are common along the left bank of the river Amur, mainly in the lower reaches of large rivers crossing the Middle Amur lowland. These rivers as a rule have gently sloping banks, formed by accumulative sand deposits in the form of extensive shoals. Bends of wide channels are irregular in shape.

Method and Materials

Small rivers at the Middle Amur Lowland, remote from man-made pollution (mining and forest industries and populated localities), which serve as water drains from reclamation systems are investigated (Table). The main approach used is the method of hydrological analogy proposed by V.G. Glushkov and developed by the Soviet hydrologists [3]. The main idea is selection and comparison of the transformed river and non-transformed river (where catchment and floodplain-channel complexes are not affected by agricultural activity).

Field data during period from 2005 to 2017 include hydrological, morphological, morphometric characteristics of FCC; 600 spot samples of water (250), soil (175) and bottom sediments (175); maps, statistical and fund data from ICARP FEB RAS are used.

Analytical equipment exploited was: atomic absorption spectrometer “Thermo Solaar 6M”; the system of microwave decomposition of samples “MARS 6”; spectrophotometer “Shimadzu UV-1800”; planetary monofilament “Pulverisette 6”; water-distiller “DE-4 (TZMOI)”; the vacuum filtering device “PVF - 47/3 N B (PP)”; pH meter “Hanna 211”; laboratory portable ionomer “ANION-4101”.

Results and Discussion

Results of the fild visual observations

The fild visual observations demonstrate that in natural conditions the lowland rivers of the Middle Amur Region are characterized by continuous erosion pavement, composed of small and medium well-rounded pebbles, filled with sand of various granularities. Coastal slopes are well expressed. Convex banks are composed of sandy sediments. Concave banks are usually steep and well fixed with vegetation.

Sandy loam and silt-clay deposits, which are up to half a meter in thickness, predominate in the composition of channels of river-water receivers. The banks are marshy, clayey, especially at the confluence of main land reclamation canals, with typical inten-

Table

Characteristics of small rivers affected by land reclamation at the Middle Amur Lowland

River	River length, km	River basin, km^2	Floodplain soil types	Reclamation area, ha (% of basin area)	Length of land reclamation canal, km
Ul’dura	15	160	Podzolic brownified clay and loam	1429 (20)	99
Gryaznushka	32	191		3139 (55)	224
Solonechnaya	52	484	Meadow clay	536 (40)	423
Vertoprashikha	42	281		3942 (30)	272
Osinovka	56	530		9854 (30)	450

sive vegetation in river beds. In the lower reaches of rivers, whose basins area has been changed by more than 35-40%, there is a large amount of undecomposed organic material with a thickness of up to 25 cm in the channels.

Beds of rivers, in the basin of which reclamation works were carried out, acquire smoothed outlines. Elements of floodplain-channel relief are practically not differentiated. In the areas of confluence of tributaries or main canals, extended shallows of irregular shape are formed. The beach is hummocky and strongly waterlogged. At the same time, a trough-like riverbed is characteristic for watercourses flowing in natural conditions. This riverbed has relatively uniform distribution of depths along the width and developed riverbed relief – from ridges and riffles to reach-shoal systems.

When the river basin is changed by more than 45-50% due to reclamation measures, the channel ceases to exist as a single linearly extended negative form of the relief. It is replaced by a system of small elongated reservoirs, which have an oval shape and are united in a single stream only during periods of increased water content (summer-autumn floods).

Field observation data and comparison of terrain plans shows that in river FCC within the reclamation systems and downstream, the horizontal deformation of channels is drastically reduced or almost completely stopped. Thus, under natural conditions during the summer-autumn floods within the bends of rivers an intensive blurring of the concave bank (up to 4.3 m/year) and the development of rectifying ducts (up to 1.2 m/year) are observed. In channels with a developed system of tributaries in the form of land reclamation channels there is only coastal encroachment without visible destruction.

As a whole, land reclamation within the FCC and catchment areas changes significantly the migration of pollutants through soil horizons and their removal to rivers [9].

Results of the spot samples of water, soil and bottom sediments analysis

The results show in spring the concentration of heavy metals in river water reaches: Fe – 2.6 mg dm^{-3}, Mn – 0.9 mg dm^{-3}, Cu – 0.03 mg dm^{-3}, Pb – 0.15 mg dm^{-3}, Zn – 0.03 mg dm^{-3}. By the winter low water the content of water-soluble forms of heavy metals increases depending on the floodplain state. For example, in dry floodplains Fe, Mn, Cu and Pb concentration increases by 1.5-2.5 times; in flooded riverbeds Fe and Mn concentration decreases by 2.5 times, Pb and Zn concentration increases by 1.5 times.

The content of heavy metals in soils of the main land reclamation canals is always higher than in the natural background, but is less than in drainage water.

Water chemical composition in the rivers, draining through reclamation systems, during seasonal water level elevation is effected by increased washout of solid metals from floodplain soils and reducuction of their concentration due to dilution. During floods, the decrease of solid Fe (by 2-4 times), Mn (by 2-90 times) and Zn (by 2 times) in river waters has been recorded; no change in Cu, Ni, and Co have been detected; in some cases Pb accumulation has taken place.

When the water fills the floodplain in the areas of reclamation systems during floods, the amount of suspended matter increases up to 3.5 times in comparison with the background. At the same time, in accordance with requirements for composition and properties of water for drinking-water facilities the concentration of suspended solids should not increase by more than 0.25 mg dm^{-3} in compare with the background.

The concentration of total organic carbon in background spots is 3.5-8.43 mgC dm^{-3}; in rivers with a developed network of reclamation channels its concentration is approximately 1.5 times higher. Organic carbon is mainly encountered in a dissolved form – from 2 to 10 mgC dm^{-3} (92%) and marginally in the form of suspended particles (less than 1 mg C dm^{-3}). Water-soluble organic substances are represented by 60% of humic and fulvic acids; their content in river basins with reclamation systems is approximately 1.5 times higher than in background ones. The concentration of fulvic acids exceeds the humic content by approximately 10 times.

Complex analysis of heavy metals content in the system "floodplain soil – water – bottom sediments" showed the moderate influence of land reclamation in FCC of rivers, whose basins have been transformed to about 15%. In these complexes the content of heavy metals, biogenic and organic substances increases (rarely above the maximum allowable concentrations). There is a slight decrease in the oxygen content and in the rate of the river water flow; surface waters are capable for self-cleaning. The greatest influence of land reclamation is manifested in river basins, which have been changed by reclamation by 20% or more. Heavy metals are intensively removed from the soil, washed away into the surface water with suspended organic material, subsequently sedimenting at the bottom. The above leads to general degradation and swamping of river valleys; their further restoration requires human intervention.

Conclusion

Development of meliorative systems in river basins of the Middle Amur Lowland leads to significant transformation of floodplain-channel complexes, their degradation and simplification, with a cease in forming of micro-, meso- and macro relief. Drainage water discharges from a drained massif through reclamation system, and changes the chemical composition of surface waters in small rivers. The discharged waters are characterized by approximately 2-fold excess of hydrogen index, ammonium nitrogen and chlorides in comparison with the natural environment. Intensive migration (removal) of suspended and organic substances, especially fulvic acids into surface water increases geochemical mobility of heavy metals and lead to worsening of water hydrochemical characteristics.

FCC in small rivers with basins drained by less than 15%, retains the ability for self-cleaning and self-recovery. When the basin is drained by more than 20%, intensive migration (removal) of heavy metals, biogenic and organic substances takes place, leading to degradation of floodplain-channel complexes, the further restoration of which requires anthropogenic interference.

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SIGNS OF CLIMATE CHANGE IN AFGHANISTAN: DROUGHT AND ITS EFFECT ON AGRICULTURE

Rafiullah Nasrati
Geoscience Center of Academy of Sciences of Afghanistan (ASA), Kabul, Afghanistan
Email: rafiullah_nasrati@yahoo.com

Afghanistan is one of the countries that have suffered the most damages from the change of climate. Over the recent decades, its temperature has increased and on the contrary, precipitation has decreased, with serious change in its special and temporal distribution. Decrease in the thickness and area of the avalanches, retreat of the snow line, decline of the ground water level, decrease of river flows, and shortage of potable water for humans, animals and irrigation are considered as other signs and effects of the climate change (CC). Occurrence of successive droughts, poverty, mass immigration, decrease of the price of cattle or their death, loss of rain-fed agriculture or its serious damage, decrease of the level of agricultural products, lack of food security, elimination of pastures, spread of human, animal and plant diseases, pollution of water, soil and air and tens of other cases have been continually caused due to the CC in Afghanistan. Although the part of Afghanistan has very little signs of the climate change, it suffers more than any other country. There are two solutions to decrease the effects of the CC in the country. First, to take preventive measures, or to be prepared before the occurrence of an incident and second, to coordinate life conditions with climate changes; all effects of the CC in Afghanistan should be considered.

Keywords: *climate, drought, rainfall, temperature, water.*

Introduction

Over the past centuries, the Earth's climate has changed, and this process has been intensified during last few decades, with unusual changes in climatic parameters (air temperature, moisture and precipitation, air pressure, etc.). These changes are the result of both of human activities (use of too much fossil burning and carbon dioxide emission to the atmosphere) and natural factors (solar winds, the movement of the Earth's plates, volcanic eruptions, atmospheric storms, etc.). No part of the planet has remained save from the effects of climate change. The warm regions have become warmer, the cool regions cooler, the damp regions damper and the dry regions drier.

Afghanistan is considered among the countries which have suffered the most damages from the change of climate. There are many signs of climate change in Afghanistan such as droughts, resulting in decrease of surface and ground water and increase in temperature and evaporation. In recent decades, precipitation has decreased and on the contrary, temperature has increased. Spatial-temporal distribution of precipitation has change seriously as well. For instance, in last days of fall, in winter and in the beginning of spring, either it never snows or it snows little or the precipitation takes place in the form of rain – the precipitation out of season which makes complete the average norm of long-term precipitation. But since it has occurred in the form of rain, it has taken place out of the season or it has melted earlier as a result of momentary increase of the temperature, people cannot store or control it. As a result, there can be a shortage of water even in the middle the year. Decrease in the thickness and area of the avalanches, retreat of the snow line, reduction of ground water level, decrease of river flows, and shortage of potable water for humans, animals and irrigation are considered as other signs and effects of the climate change.

Afghanistan is an agricultural country, with total area 652225 km^2 or 65222500 mln ha. Out of the total area of the country, almost 12% is agricultural land, 3% – forest, 46% are permanent pastures, and 39% are covered by mountains and urban areas. 76000 km^2 (7.9 mln ha), or 12.11% of total area is cultivatable land, 5.3 mln ha of which are irrigable and the rest 2.6 mln ha cannot be irrigated. Out of 5.3 mln ha of irrigable land, only 2.6 mln ha are irrigated due to shortage of water and 2.7 mln ha cannot be cultivated due to the lack of barriers, canals, or have no controlled running waters and lacks its sound management.

It is obvious that almost two third of the population of Afghanistan is busy in agriculture, livestock husbandry and related affairs, which are most vulnerable to drought, because they depend on water. The present work focuses on droughts and their effect on agriculture, agricultural crops and livestock husbandry in Afghanistan.

Drought and Wet Periods in Afghanistan

Over the past half-century, Afghanistan has experienced numerous droughts of different severity. Figure 1 and Table 1 show the drought and wet years, their frequency and severity; drought and wet classification and occurrence percentage are given in Tables 2 and 3.

Figure 1 and Table 1 indicate that the years when precipitation is less and the drought has occurred the level of agricultural crops has also decreased, and on the contrary, in the years when precipitation is higher, the level of agricultural crops has also increased. The relation of drought with the level of agricultural crops has been studied briefly as follows.

Whenever the precipitation decreases, agriculture and livestock husbandry sustain serious damage. For example, in 1970 and 1971 when Afghanistan received precipitation under normal which caused drought, agricultural crops considerably decreased. Meanwhile, livestock husbandry has also been affected. Agricultural land was 0.55 ha per capita in 1980, which decreased to 0.25 in 2007. Successive droughts, especially from 1998 to 2004 caused destruction to many agricultural lands and damaged pastures.

As two third of active population of the country depends on agriculture, more than half of Afghanistan's population suffers during droughts. Almost 85% of all crops in the country are obtained through traditionally irrigated farming. Since 1978, the irrigable area has almost decreased by 60% and changed Afghanistan, which has evolved from near 'self-sufficient' in agricultural crops to a main importer of grains, fruit and vegetables. Therefore, it can be concluded that the droughts have caused a lot of damages in this sphere.

Similarly, gardens, forests, pastures and forest lands of the country have suffered irreparable damage. For example, exporting dry fruit and nuts, especially apricots and almond which is still considered one of the important sources of foreign currency; is not as much as in 1980 when dried fruit of the country has occupied 60% of the world markets.

Effect of drought on wheat production

The effect of drought on wheat production which is the most essential agricultural crop in Afghanistan is estimated. Wheat is among the main and principal agricultural crops which constitutes almost 83% of total expenses of grains of the country. Since its cultivation and amount of production depends on precipitation, and because there is less precipitation than normal in most regions of the country from late 2007 (October) to the middle of 2008 (May), which had caused the drought, the NGOs reported the condition of rain-fed wheat, especially in the north and the west of the country. According to the report of the Afghanistan government, the crop of irrigated wheat

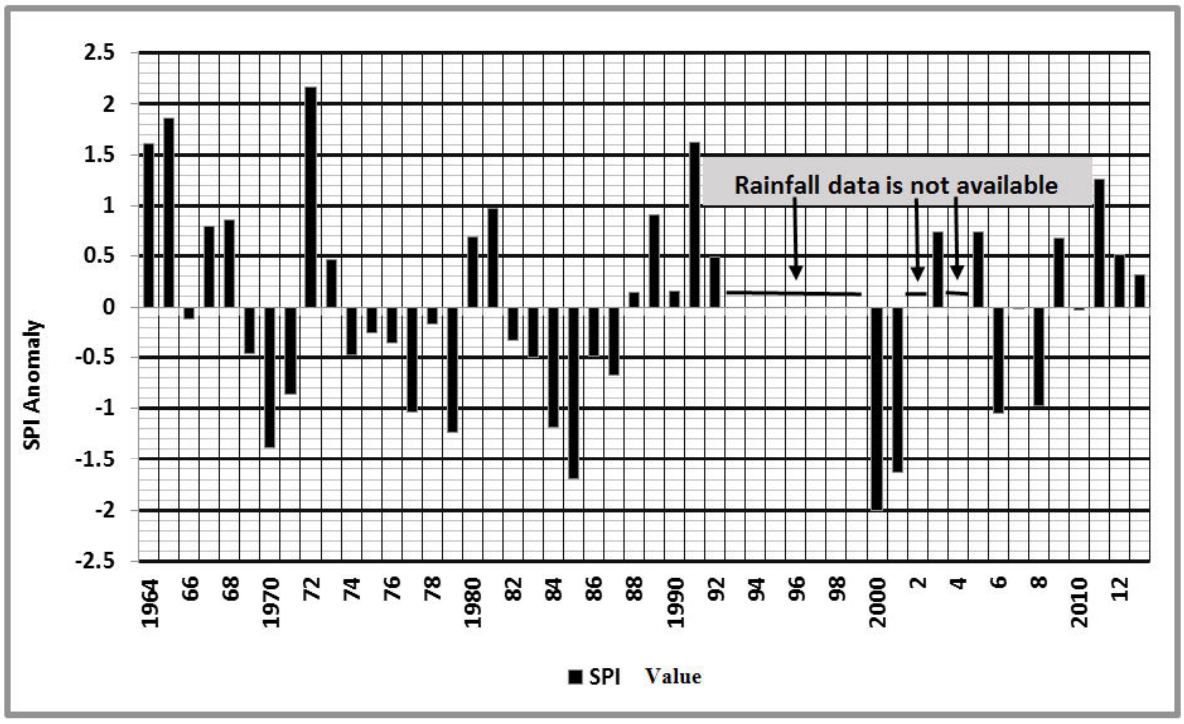

Figure1. Drought and wet years, their frequency and severity in Afghanistan [3, 4]

Table 1

Statistics of drought and wet years, periods and severity in Afghanistan, 1964–2013 [3, 4]

No	Years	Drought and wet value	Drought and wet periods		Drought and wet severity							
					Drought				Wet			
			drought	wet	MD	MeD	SD	ExtD	MW	MeW	SW	ExtW
1	**1964**	**45.76**		first								
2	**1965**	**52.96**										
3	**1966**	**–3.27**	first									
4	**1967**	**22.68**		second								
5	**1968**	**–24.5**	second									
6	**1969**	**–13.22**										
7	**1970**	**–39.29**										
8	**1971**	**–24.54**										
9	**1972**	**61.54**		third								
10	**1973**	**13.18**										
11	**1974**	**–13.56**	third									
12	**1975**	**–7.39**										
13	**1976**	**–10.13**										
14	**1977**	**–29.34**										
15	**1978**	**–4.65**										
16	**1979**	**–35.17**										
17	**1980**	**19.69**		fourth								
18	**1981**	**27.58**										
19	**1982**	**–9.45**	fourth									
20	**1983**	**–14.25**										
21	**1984**	**–33.8**										
22	**1985**	**–48.21**										
23	**1986**	**–13.91**										
24	**1987**	**–19.05**										
25	**1988**	**3.92**		fifth								
26	**1989**	**25.87**										
27	**1990**	**4.26**										
28	**1991**	**46.10**										
29	**1992**	**13.86**										
30	**1993**	Rainfall data is not available										
31	**1994**											
32	**1995**											
33	**1996**											
34	**1997**											
35	**1998**											
36	**1999**											

Continuation of the Table 1

37	**2000**	**–57.12**	fifth									
38	**2001**	**–46.49**										
39	**2002**	Rainfall data is not available										
40	**2003**	**21.071**		sixth								
41	**2004**	Rainfall data is not available										
42	**2005**	**21.07**										
43	**2006**	**–29.68**										
44	**2007**	**–1.56**	sixth									
45	**2008**	**–27.99**										
46	**2009**	**19.18**		seventh								
47	**2010**	**–0.81**	seventh									
48	**2011**	**35.75**										
49	**2012**	**14.69**		eighth								
50	**2013**	**8.96**										

M D	**Me D**	**S D**	**Ext D**	**M W**	**Me W**	**S W**	**Ext W**
Mild Drought	Medium Drought	Serious Drought	Extreme Drought	Mild Wet	Medium Wet	Serious Wet	Extreme Wet

60% or 1.5 mln t than in previous year. The decrease of winter grain crop caused the Afghanistan government and the UN to demand for 400 million US dollars from the United Nations for importing additional wheat and other food stuff for 4.5 mln people who were suffering from the drought.

The less precipitation, the less will be cultivated and rain-fed wheat area and crop per hectare. According to USDA assessment [5], the amount of wheat production had decreased by almost 55% and the barley by 67 % compared to 2007. Similarly, decrease of wheat in domestic markets caused an increase in its price by 200 %.

Estimations based on Central Statistics Organization report [1] show that about 1.25 mln ha of land are cultivated as rain-fed in Afghanistan and the most ness of the agriculture sector. When the amount of precipitation was less than normal in 2008 and there was drought in the country, the spread and growth of plants was less than the normal and the plants were in bad condition (Figure 3). On the contrary, the amount of precipitation was normal even more than normal in 2009 and it was considered as a wet year, the spread and growth of the plants enjoyed good conditions.

As mentioned above, the production of grains, especially wheat depend more on the weather condition and precipitation. 25% of the rain-fed lands are allocated for the cultivation of wheat and this amount varies annually (Figure 4).

It should be noted that rainfall data of the Ministry of Agriculture, Irrigation and livestock husbandry [4] did not show the 2011 as metrological drought

Table 2
Drought classification and occurrence percentage [3, 4]

No	Drought classification	Percentage of occurrence
1	Mild	**68.181**
2	Medium	**22.727**
3	Serious	**4.545**
4	Extreme	**4.545**
5	Total	**100**

Table 3
Wet years classification and occurrence percentage [3, 4]

No	Wet classification	Percentage of occurrence
1	Mild	**73.682**
2	Medium	**5.263**
3	Serious	**15.789**
4	Extreme	**5.263**
5	Total	**100**

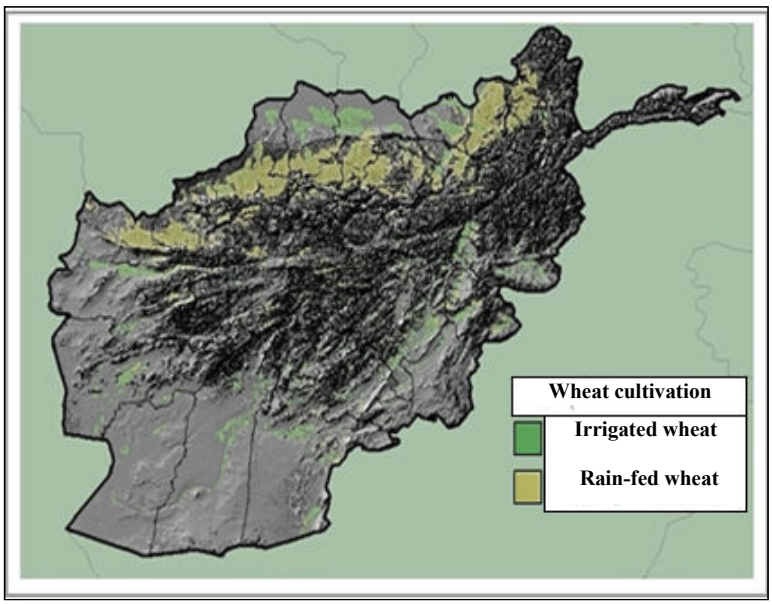

Figure 2. The irrigated and fain-fed wheat cultivation area in Afghanistan [1]

and, in total, it was a normal even wet year, but it rained in this year untimely and caused agricultural drought as a result of which the production of irrigated and rain-fed wheat considerably decreased. Due to less water and lack of precipitation in April and May, the crop of rain-fed wheat decreased. Also, the irrigated wheat was damaged in each part of the country, especially the north and northwest was damaged seriously. As a result, in 2011 the irrigated wheat crop decreased by 28% and the rain-fed – by 77%. Irrigated and rain-fed wheat crop showed a decrease by 14% and 17%, respectively, in 2010, compared to 2009.

Annual change in grains production over the recent 14 years (from 1998 to 2011) shows that 1998, 2003, 005, 2007 and 2009 are considered as good (Table 4).

On the contrary, the level of grains production decreased due to the droughts in 1990, 2000, 2001, 2002, 2004, 2006, 2008, 2010 and 2011, negatively affecting on agricultural production as a whole.

Conclusion

The effect of drought on the level of agricultural crops, especially irrigated and rain-fed wheat in period from 2012 to 2018 has been studied. In the current 2018, year 21 provinces of Afghanistan face an unprecedented drought. This year, due to shortage of water, foodstuff and herbs for animals thousands of people, especially from Ghor and Badghees provinc-

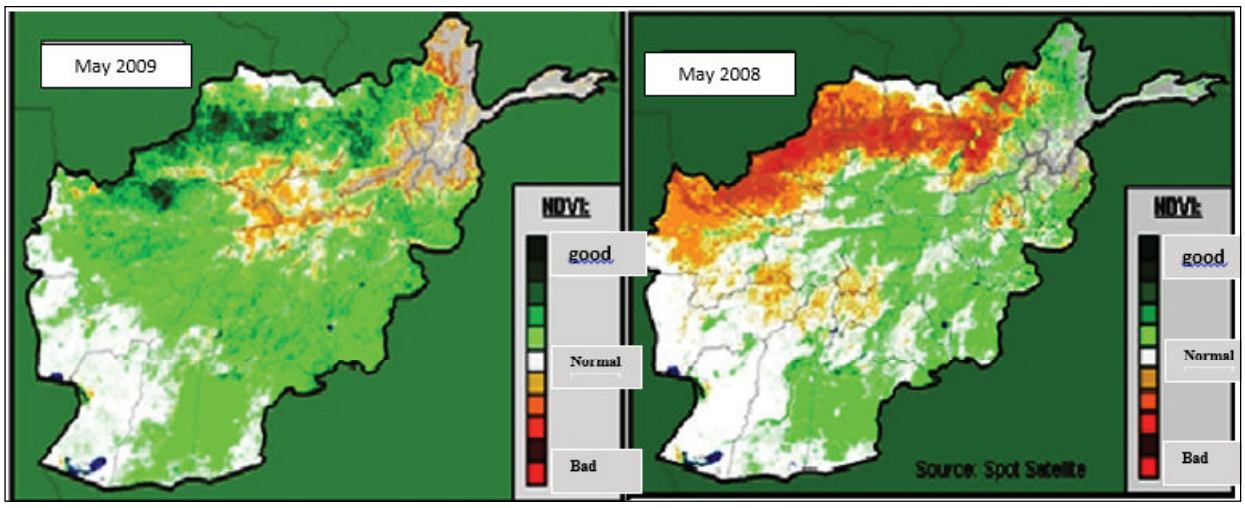

Figure 3. The comparison of plant condition of Afghanistan in 2008 and 2009 [5]

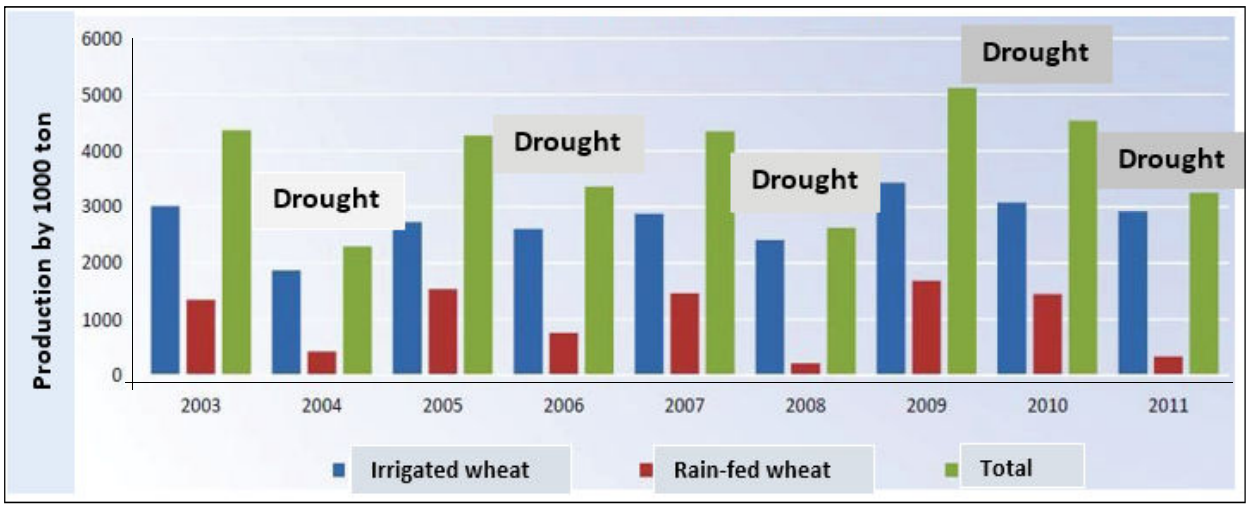

Figure 4. Irrigated and rain-fed wheat production chart from 2003 to 2011 by metric ton, Afghanistan [2]

es had to leave their homes. Nearly two million livestock (cows, bulls, sheep, and goats) died. In the same manner, this year (2018) Afghanistan faces lack of an amount of 1.5 mln tons of wheat. There are two solutions to slightly reduce the effect of climate change in Afghanistan. First, to take preventive measures to be prepared before the occurrence of the incident and second, to coordinate life conditions with climate change. Therefore, all effects of the climate change in Afghanistan, such as droughts should be taken into account.

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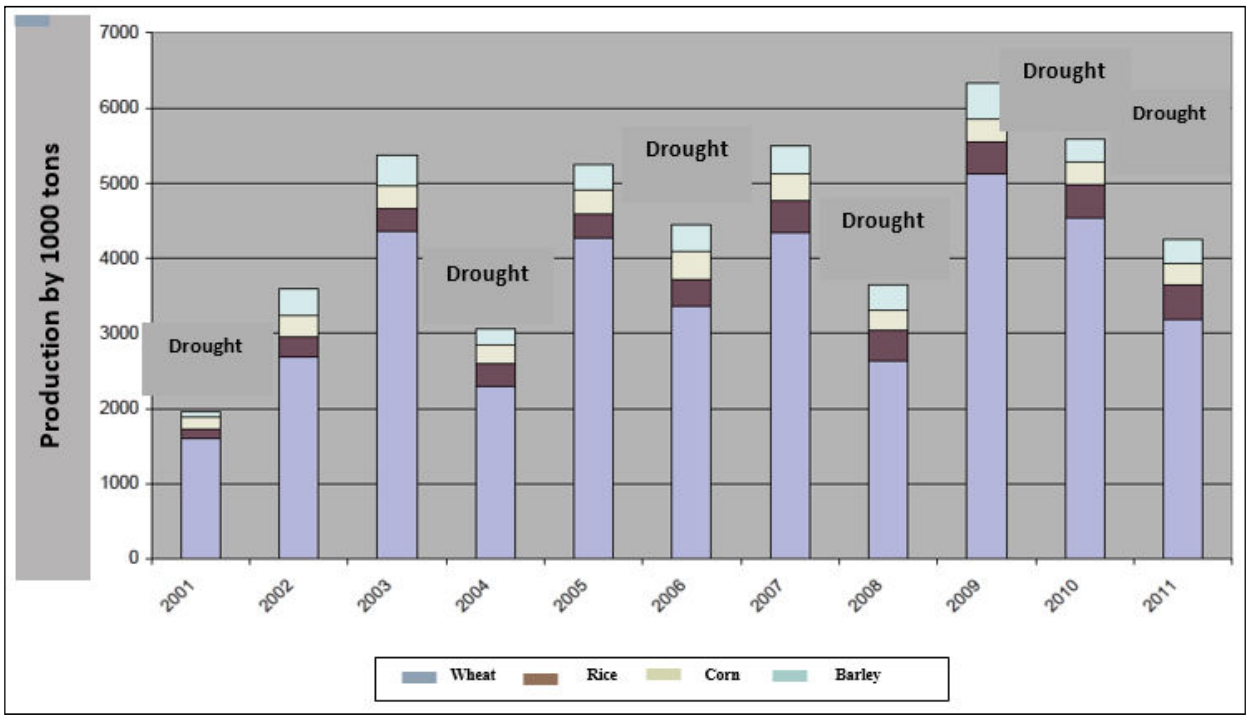

Figure 5. The production of grains chart of the country from 2001 to late 2011, Afghanistan [2]

Table 4

Relation of drought with the production of grains in Afghanistan from 2003 to 2011, by 1000 tons [2]

Irrigated wheat	Rain-fed wheat	Irrigated and rain-fed wheat	Rice	Corn	Barley	Total	Years	No
2020	814	2834	301	330	240	3705	1998	1
1988	512	2500	188	240	216	3144	1999	2
1329	140	1469	105	115	74	1763	2000	3
1514	83	1597	122	160	87	1966	2001	4
2110	576	2686	260	298	345	3589	2002	5
3017	1345	4362	291	310	410	5373	2003	6
1867	426	2293	310	234	220	3057	2004	7
2728	1538	4266	325	315	337	5243	2005	8
2604	759	3363	361	359	364	4447	2006	9
2878	1465	4343	425	360	370	5498	2007	10
2406	217	2623	410	280	333	3646	2008	11
3433	1682	5115	432	300	486	6333	2009	12
3082	1450	4532	450	301	437	5720	2010	13
2917	339	3256	450	301	305	4312	2011	14

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UDK 502.2(511)

PHENOPHASE SHIFTS ACROSS ELEVATIONS ON MAJOR MOUNTAINS IN NORTH CHINA

Junhu Dai[1,2]*, Mengyao Zhu[1,2], Huanjiong Wang[1], Quansheng Ge[1,2]*
[1]Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China
[2]University of Chinese Academy of Sciences, Beijing, China
Email: daijh@igsnrr.ac.cn, geqs@igsnrr.ac.cn (* co-corresponding authors)

Previous studies have reported plant phenological changes along horizontal belts in North China, however, little is known about elevation effects on mountain phenophases in China, such as how vegetation phenophases shift across elevation on mountains, and how they change under background of global change. In this context, by application of remote sensing data, Moderate Resolution Imaging Spectroradiometer (MODIS), changes of spring phenophases across elevation on 6 typical mountains in North China, namely Wuling, Xiaowutai, Guandi, Migang, Huashan and Taibai Moutians, and the effects of elevation on phenophases along altitudinal gradients, were studied in current work. Preliminary results showed that, similar to our findings of phenological changes in plain area in North China, the onset of vegetation phenophases in spring advanced on these mountains, while the ending time for autumn phenophases delayed in the past two decades. Trends for advanced spring phenophase increased significantly with altitude in some mountain regions, and spring phenophase sensitivities to altitude are stronger in lower latitude than in higher latitude regions. Similar to foreign studies, it is reported for the first time that global warming has led to a more uniform spring phenology across elevation in North China mountains in recent years. Findings will not only benefit policy making for the government in the field of ecological constructions, but also will be helpful to evaluate future climate change on vegetation in such areas.

Keywords: *spring phenology, global change, mountain, North China.*

Introduction

Although a variety of studies have revealed distributions of spring phenophases and their shifts across horizontal gradients in North China [1-3], little is known about elevation effects on phenophases across different elevation on mountains, or on phenological shifts under background of global warming in China. It is learned from studies on mountains in Europe [9] that global climate change has altered bio-climatic law regarding the phenological shifts across elevations [5] by contracting the elevation-induced shift in the time of spring phenophases in four common tree species in Swiss Alps between low and high elevation by 35%. However, it is more interesting to know if the observed contraction in elevation-induced shifts in spring phenophase is a local pattern in the European Alps or is also happening in other regions of the world along elevation and latitudinal gradients [8]. In this context, by studying spatial and temporal changes of spring and autumn phenophaeses through remotely sensed data on typical mountains in north China, we aimed to examine: (1) whether the trend of phenophase shifts is consistent along elevation gradients; (2) whether altitudinal sensitivity of phenophase is constant over time on each of these mountains.

Data and methods

The study area is in North China (30°–40°N, 100°-135°E), which is comparatively rich in temperate or subtropical flora components, with wide distribution of broadleaved deciduous forest. This research focused on 6 typical mountains (200×200 pixels in MODIS imagery or 1°×1° per site) along latitude gradients throughout the study area (Figure 1), namely Wuling, Xiaowutai, Guandi, Migang, Huashan and Taibai from north to south. All the mountains studied are dominated by broadleaved deciduous forest and are characterized by abrupt slopes and altitudes over 2000 meters above sea level (m. a. s. l.). We derived phenological metrics from time series of NDVI products processed by Liu and Liu [6] through Moderate Resolution Imaging Spectroradiometer (MODIS) imageries with spatial and temporal resolution of 500 m and 8-days, respectively. An inflexion-based cloud detection algorithm was proposed in the above work and performed generally better than other cloud masks accompanying with the MOD09 products [6]. The Digital Elevation Model (DEM) data set was produced by the Shuttle Radar Topography Mission (SRTM) project, with 30m spatial resolution. The vegetation data sat was extracted and rasterized from

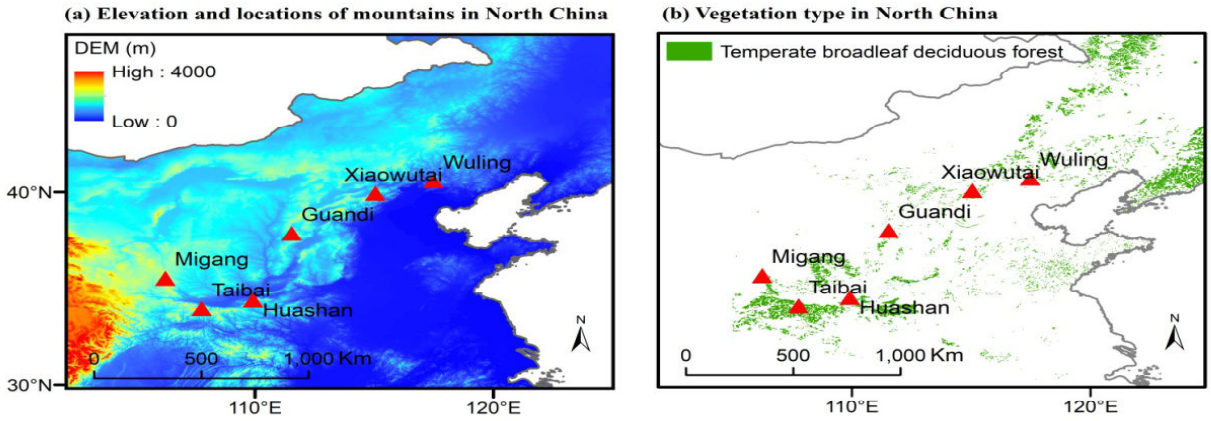

Figure 1. Locations of typical mountains in North China: (a) elevation in North China; (b) distribution of temperate broadleaf deciduous forest in North China

1:1 000 000 Vegetation Map of China, which was produced by Chinese Academy of Sciences from the land resource investigation (http://westdc.westgis.ac.cn) [4]. The only vegetation type we studied was the temperate broadleaf deciduous forest. Both DEM and vegetation type data were resampled to 500m spatial resolution to match the MODIS NDVI products.

We examined the growing season shifts between 2001 and 2017. The double logistic model (DL) approach was applied for the gap filling of NDVI time series. With reference to Shang et al. [7], the threshold at the inflexion point is 9.18% of vegetation growth amplitude, and thus, a dynamic threshold of 9.18% was used to extract inflexion point of NDVI. Seasonal phenological metrics for start-of-season (SOS) and end-of-season (EOS) were extracted pixel-by-pixel for 2001 through 2017. SOS and EOS were then masked by temperate broadleaf deciduous forest type on the vegetation map. A simple linear regression model between phenological metrics and corresponding years was applied to calculate the trend of SOS and EOS. For each mountain, the trend of phenological metrics was summarized, as advancing (trend < 0), delaying (trend<0), significant advancing (p-value < 0.05), and significant delaying (p-value < 0.05). Trends for SOS and EOS during the study period were then averaged along altitude gradients respectively to test whether they were consistent along altitudinal gradients. Finally, the phenological sensitivity to altitude (altitudinal sensitivities) was calculated during the study period for each mountain.

Results

Phenological trend on major mountains in North China

Similar to phenological shifts in spring and autumn in plain areas, a general advancing of the spring phenophase and a delaying of the autumn events were found in most part of the study area (Table 1). From 2001 to 2017, SOS advanced in 73.3%-99.4% pixels and significantly advanced in 2.1%-26.3% pixels on all 6 typical mountains in North China, while EOS delayed in 71.2%-90.4% pixels on most typical mountains except Wuling, and in 3.2%-22.4% pixels the delaying trend is significant. Overall, growing season length for the mountain temperate broadleaf deciduous forest on these mountains extended during the study period. This is similar to results we obtained for phenological shifts along horizontal belt in temperate areas in China in the last few decades [3].

Trend of SOS and EOS along altitude gradients

We analyzed changes of trend for SOS and EOS respectively across the altitudinal gradients, and found that, (1) trends for SOS increase significantly with altitude from lower elevations to higher elevations in half of the 6 mountains, namely, Migang, Huashan and Taibai (Figure 2: (d), (e) and (f)); but it shows no clear tendencies on two mountains, Wuling and Guandi, and a decreasing tendency along altitude from lower elevations to higher elevations on Mountain Xiaowutai is found. Overall, it is showed that the tendency for SOS trend across altitude gradients increase with elevations. (2) However, the tenden-

Table1

Summary on the percentage of SOS trend and EOS trend for 6 mountains in North China. The phenological metrics trend was classified as advancing-, delaying, significant advancing (p-value < 0.05), and significant delaying (p-value < 0.05)

Phenophase	Mountain name	Percentage for different shift trend			
		Advancing	Delaying	Significant advancing	Significant delaying
SOS	Wuling	99.4%	0.6%	26.3%	0.0%
	Xiaowutai	98.6%	1.4%	16.8%	0.0%
	Guandi	85.4%	14.6%	6.2%	0.0%
	Migang	85.4%	14.6%	9.3%	0.2%
	Hua	83.3%	16.7%	4.5%	0.8%
	Taibai	73.3%	26.7%	2.1%	0.3%
EOS	Wuling	46.2%	53.8%	1.5%	1.2%
	Xiaowutai	24.3%	75.7%	0.4%	3.2%
	Guandi	28.8%	71.2%	0.4%	7.0%
	Migang	26.6%	73.4%	0.3%	4.7%
	Hua	9.6%	90.4%	0.1%	22.4%
	Taibai	18.8%	81.2%	0.2%	9.3%

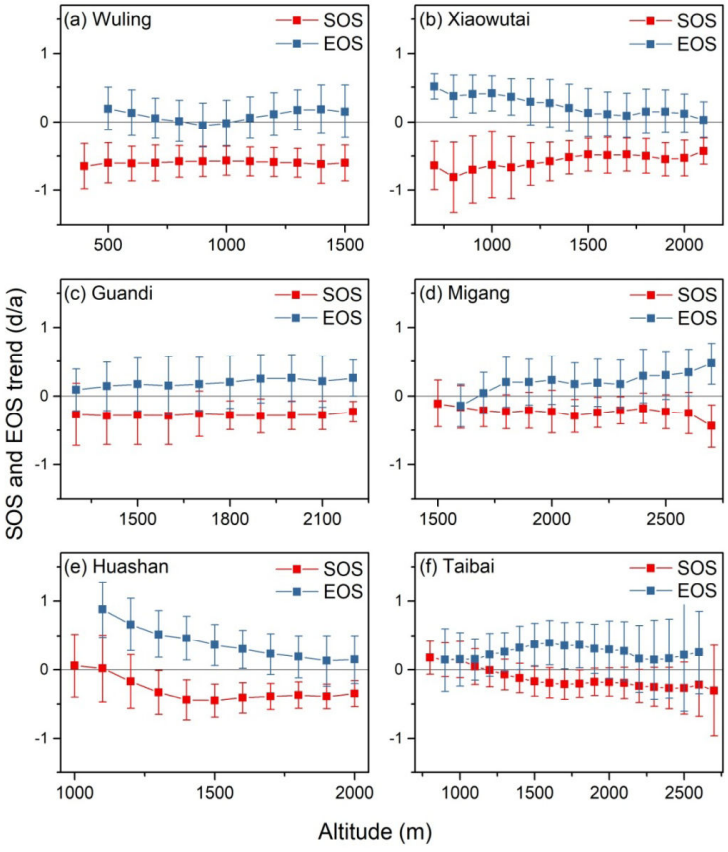

Figure 2. SOS and EOS Trend (d/a) along altitude gradients for 6 typical mountains in North China. Panel (a)–(f) represent SOS and EOS Trend (d/a) on mountain Wuling, Xiaowutai, Guandi, Migang, Hua and Taibai respectively. SOS Trend is marked by red square, and EOS Trend is marked by blue square. Error bars represent standard deviation of Phenological trend within 100 m interval of altitude

Table 2

Summary on correlation analysis between SOS/EOS trend and altitude.
Pearson's R represents Pearson correlation coefficient.
The significance is indicated with '*' (p-value < 0.05)

Mountain		Summit elevation(m)	Longitude,°E	Latitude, °N	Pearson's R	P-value
SOS	Wuling	2116	117.5	40.6	0.286	0.367
	Xiaowutai	2882	115.0	39.9	0.835*	0.000
	Guandi	2830	111.5	37.9	0.382	0.276
	Migang	2931	106.2	35.6	−0.655*	0.015
	Huashan	2155	109.9	34.4	−0.729*	0.011
	Taibai	2767	107.8	34.0	−0.965*	0.000
EOS	Wuling	2116	117.5	40.6	−0.044	0.891
	Xiaowutai	2882	115.0	39.9	−0.939*	0.000
	Guandi	2830	111.5	37.9	0.908*	0.000
	Migang	2931	106.2	35.6	0.862*	0.000
	Hua	2155	109.9	34.4	−0.955*	0.000
	Taibai	3767	107.8	34.0	0.010	0.969

cies for EOS trends changing with altitude on these 6 mountains (Figure 2 and Table 2) are quite complicated, as they decrease significantly in Xiaowutai and Huashan along altitudinal gradients from lower elevations to higher elevations, but increase along altitudinal gradients from lower elevations to higher elevations on Migang mountain and Taibai mountain, with the former showing significant increase. The tendency for EOS trend along the altitudinal gradients on Wuling is not manifest. (3) The changing tendencies for both SOS and EOS along altitudinal gradients from lower elevation to higher elevation on two mountains, Migang and Taibai are similar, increasing with altitude.

Altitudinal sensitivity trends over time

In 6 North China mountains, we found the altitudinal sensitivity of SOS is smaller at high latitudes than at low latitudes. Figure 3 shows average altitudinal sensitivity of SOS on 6 typical mountains during 2001-2017. Along latitude gradients, the mountains in higher latitudes have significantly smaller altitudinal sensitivity than lower latitudes, and this is in accordance with studies in European mountains [8]. For example, Mountain Wuling (40.6°N) has lower altitudinal sensitivity than Mountain Huashan (34.4°N) and Mountain Taibai (34.0°N). At low latitudes, response of plant phenology to altitude tends to be stronger, which is similar to the previous study conducted by Vitass et al. [9].

Generally speaking, the altitudinal sensitivity of SOS showed a decreasing tendency from 2001 to 2017. This shows the conclusions that global climate change in recent decades leads to more uniform spring phenology across elevations [9], drawn from studies of shifts of spring phenophase on European Alps are also suitable on North China mountains. The results

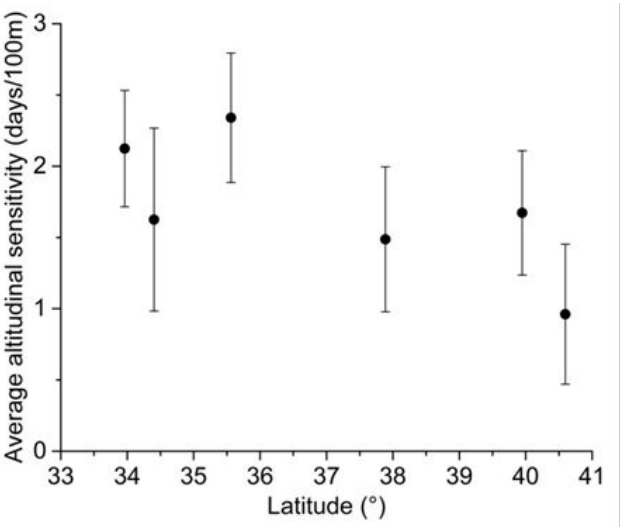

Figure 3. Average altitudinal sensitivity of SOS on 6 typical mountains along latitude gradients. Error bars represent 1 σ altitudinal sensitivity uncertainties during 2001–2017

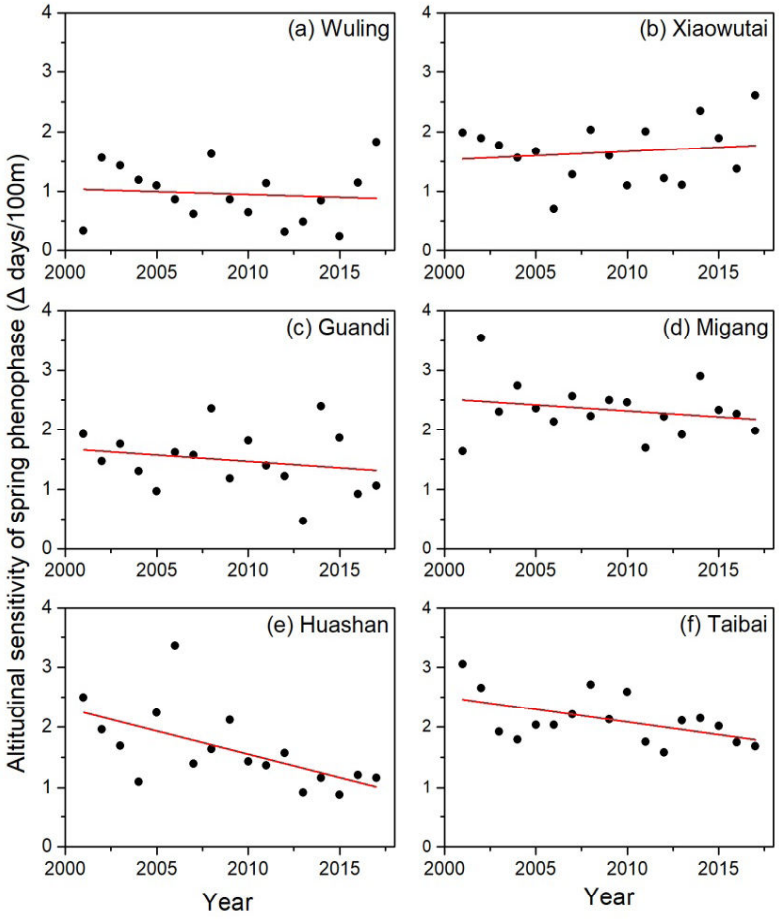

Figure 4. Time series of altitudinal sensitivity of SOS for 6 mountains in North China, panel (a) to (f) represent different mountains in North China, and the red lines are linear fits by regression analysis

of linear regression analysis indicate that altitudinal sensitivity of SOS is negative related to year for 5 of the 6 mountains we studied, except Xiaowutai (Figure 4). Among them, altitudinal sensitivity of spring phenophase of Huashan and Taibai exhibit significant decreasing trend. During 2001 and 2017, altitudinal sensitivity of SOS in these 2 mountains has decreased by 0.042–0.077 days/100m per year (p-value < 0.05) (Table 3). At low latitudes, the dates of SOS became closer between higher and lower altitudes, because the altitudinal sensitivity of SOS has decreased 0.71–1.31 days/100m from about 3 day /100m during the last 17 years. However, at high latitudes, there is no significant change in SOS altitudinal sensitivity over time. Change of EOS altitudinal sensitivity is also not significant in last 17 years. In general, altitudinal sensitivity of SOS has become lower at low latitudes from 2001 to 2017 due to the underlying warming trend, while altitudinal sensitivity of SOS at higher latitudes or altitudinal sensitivity of EOS has no significant change.

Conclusions and discussions

We studied phenological changes on 6 high mountains in North China, and found preliminarily the following facts. (1) Similar to phenological studies relating to plain area in North China, growing season length for the mountain temperate broadleaf deciduous forest on these mountains extended during the study period, as results of advances of SOS and delay of EOS. (2) SOS and EOS trends along altitudinal direction are very important for mountain ecological studies. Overall, the tendency for SOS trends across altitude gradients increase with altitude from lower elevations to higher elevation in most of the 6 mountains studied. However changes for EOS trend along with elevation did not show very manifest ten-

Table 3

Results of linear regression analysis of Altitudinal sensitivity time series. Slope represents the change of Altitudinal sensitivity (d/100m) per year during 2001 and 2016. The significance is indicated with '*' (p-value < 0.05) and '·' (p-value < 0.1)

Mountain		Summit elevation(m)	Longitude,°E	Latitude, °N	Slope	P-value
SOS	Wuling	2116	117.5	40.6	−0.009	0.70
	Xiaowutai	2882	115.0	39.9	0.014	0.57
	Guandi	2830	111.5	37.9	−0.021	0.41
	Migang	2931	106.2	35.6	−0.020	0.39
	Huashan	2155	109.9	34.4	−0.077*	0.01
	Taibai	3767	107.8	34.0	−0.042*	0.03
EOS	Wuling	2116	117.5	40.6	−0.008	0.75
	Xiaowutai	2882	115.0	39.9	−0.042	0.11
	Guandi	2830	111.5	37.9	0.021	0.58
	Migang	2931	106.2	35.6	0.041·	0.07
	Huashan	2155	109.9	34.4	−0.060	0.12
	Taibai	3767	107.8	34.0	−0.012	0.51

dencies. (3) As far as the altitudinal sensitivities of SOS and EOS are concerned, the former showed a decreasing trend in the last 17 years, especially at low latitudes, while the later has no clear trend during the study period. This is the report from China for the first time that global warming also leads to more uniform spring phenology across elevations on mountains in North China. Characteristics of these changes over time or altitude may be attributed to climatic factors' changes, especially the temperature changes and the number of chilling days as indicated by Vandvik et al. [8]. Calculation of temperature changes, the statistics of number of chilling days on these mountains, as well as the relationship between climatic variables and phenological changes will be our future work.

The mean annual temperature in different places on mountains decreases with altitude. In Europe to north Asiatic regions, for each additional 100 m in altitude, the temperature drop is approximately the same as the mean annual decrease in temperature over a distance of 100 km on lower altitude from lower latitude to higher latitude. The width of the altitudinal belts on mountains is 1000 times narrower than the vegetation zones in the lower land from south to north [10]. However, the change patterns for climate variables along elevation gradients on mountains and along horizontal direction in plain areas from south to north are quite different. Therefore, comparison of vegetation phenology and phenological shifts on mountains and in lower latitudes are very crucial under background of global warming and worth further study.

Acknowledgements

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UDK 551.510(520)

ISOTOPIC SOURCE APPORTIONMENT OF CARBONACEOUS AEROSOLS OBSERVED IN NOTO REGION, JAPAN: IMPACT OF BIOMASS BURNING ON THE EAST ASIAN OUTFLOW

Atsushi Matsuki[1]*, Reina Yamada[2], Kento Kinouchi[2], Yoko Iwamoto[3], Fumikazu Ikemori[4], Masayo Minami[5] and Toshio Nakamura[5]
[1]Institute of Nature and Environmental Technology, Kanazawa University, Kanazawa, Japan;
[2]Graduate School of Natural Science and Technology, Kanazawa University, Kanazawa, Japan;
[3]Graduate School of Biosphere Science, Hiroshima University, Hiroshima, Japan;
[4]Nagoya City Institute for Environmental Science, Nagoya, Japan;
[5]Institute for Space-Earth Environmental Research, Nagoya University, Nagoya, Japan;
Email: matsuki@staff.kanazawa-u.ac.jp (*corresponding author)

Recent observation revealed that submicron aerosol particles in Northeast Asia have a variable but relatively high mass fraction (approximately 50%) of carbonaceous matter throughout the year. In order to investigate on their source and transport pathways, the radio carbon isotope (^{14}C) concentration within fine carbonaceous particles collected at NOTO Ground-based Research Observatory (NOTOGRO, 37.45ºN, 137.36ºE) were analyzed from 26th Jun, 2014 to 17th June, 2015. The results showed that contribution of carbonaceous matter originating from fossil fuel burning is generally small (30 pMC; percent modern carbon), whereas that from modern biological activity and/or biomass burning is large (70 pMC). Concentration of ^{14}C in autumn samples were the highest in all seasons (90 pMC), and there were indications that large scale agricultural waste burning in Northeast China was the likely source. Also, sporadic peak of modern carbon was observed which can be attributed to the plume from Siberian forest fire in summer.

Keywords: *Aerosols, carbon isotopes, biomass burning, long-range transport.*

Introduction

According to a recent report by WHO [9], estimated number of premature deaths attributable to ambient air pollution mounts up to 3.7 mln per annum globally, and fine particulate matters (or aerosols) found in high density in the polluted air are largely responsible for the motility. Also, aerosols and clouds seeded by them both affect the heat budget of the Earth's atmosphere, but their RF (radiative forcing) still involves large uncertainty [4]. Reducing such uncertainty is critical in understanding how sensitive the earth's climate would respond to any changes we make on the particulate density and composition.

One of the least understood characteristics of aerosols affecting above issues is related to the complex source and roles of the carbonaceous aerosols (including organic and soot particles) in the atmosphere. Even the latest generation of numerical models tends to underestimate the observed concentration of organic aerosols and this is particularly true in regions (e.g., East Asia) where anthropogenic and biogenic emissions mix together. The East Asia is also identified as one of the global hotspots of atmospheric aerosols. The outflow of atmospheric pollutants is increasingly concerned in connection with their impacts not only on public health but also on regional climate.

Carbon trapped in fossil fuels such as coal and oil (which is burried undergraound for millions of years) is deplete in ^{14}C since it is a radioactive isotope of carbon that decay with a half life time of 5730 years. Whereas modern biomass has a characteristic ^{14}C ratios that is basically the same as the CO_2 found in the atmosphere, as plants fix carbon through photosynthesis at the primary productive stage. As a result, it is possible to distinguish and apportion the source of carbonaceous aerosols originating from fossil fuel and modern biomass by analyzing ^{14}C concentrations and deriving fossil and modern (non-fossil) carbon ratios.

In order to better characterize the sources of carbonaceous aerosols in the background East Asian outflow region for an extended period, $PM_{2.5}$ samples were collected weekly continuously for a year in Noto area (at a remote site on the western coast of main island Japan). In addition to ^{14}C radio carbon analysis, other parameters including biomass burning tracers, $\delta^{13}C$ stable carbon isotope, BC, $PM_{2.5}$ concentrations,

MODIS satellite product and back trajectory analysis were combined to better explain the aerosol carbon sources and their seasonal variation.

Materials and Methods

The Noto peninsula projects north from the western coast of central Honshu, the main island of Japan. It can be regarded as a remote coastal site facing toward the Asian continent, which is isolated from major cities and industrial activities by the surrounding sea. Such location is considered ideal for monitoring background aerosol properties in central Japan without the significant influence from local anthropogenic sources [5, 8], as well as for sensitively detecting slightest changes occurring in the atmospheric constituents carried along by the outflow of continental air-mass. The geographic location of ground-based research station "NOTOGRO" (acronym for NOTO Ground-based Research Observatory) at the tip of Noto peninsula (37.45ºN, 137.36ºE) is shown in Figure 1.

$PM_{2.5}$ samples at NOTOGRO were collected weekly from 26th Jun, 2014 to 17th June, 2015. Two staged high volume air-sampler coupled with a $PM_{2.5}$ impactor (HV-700R, SIBATA Scientific Technology Ltd.) was installed at the roof of the three-story building approximately 13 m above ground level. The suction pump of the sampler is based on brushless blower, thus free from rotary vanes that can potentially contaminate the carbon analysis. The results presented in this work are based solely on the analysis of fine mode $PM_{2.5}$ fraction collected on the backup filter of the 2 staged high volume air-sampler.

Quartz fiber filters (Pall Corporation, 2500QAT-UP) were preheated at 450ºC for 2 hours in an electric oven in order to remove organics in the filter background prior to sampling. After continuously sampling for a week period at a flow rate of 700 L min^{-1}, the recovered filter was kept in a freezer to avoid loss of volatile components until it is extracted and analyzed.

The post sample treatment procedure is basically identical to what is described elsewhere [2]. The graphite samples prepared by the post sampling treatment were loaded in an aluminum target, and the carbon isotopic composition were analyzed by the accelerator mass spectrometry ^{14}C system (High Voltage Engineering Europe, Model 4130-AMS) at the Institute for Space-Earth Environmental Research, Nagoya University. In addition, the other parameters including concentrations of specific organic compounds, $\delta^{13}C$, black carbon, $PM_{2.5}$ and back trajectory analysis were combined to better constrain the carbon sources.

Results and Discussion

The sampling and radiocarbon analysis by this study provided almost a year-round data set of weekly ^{14}C concentrations found in the fine-mode carbonaceous aerosols in the remote coastal region in central Japan. The seasonal variation of the ^{14}C concentration is shown in Figure 2 as the time series of obtained pMC (percent modern carbon) values. The plots are shown for total 27 samples in which we successfully recovered >90% carbon as graphite during the sample processing.

Despite the remoteness of the sampling site from major industrial and urban activities, we have seen nevertheless, significant seasonal variation in ^{14}C

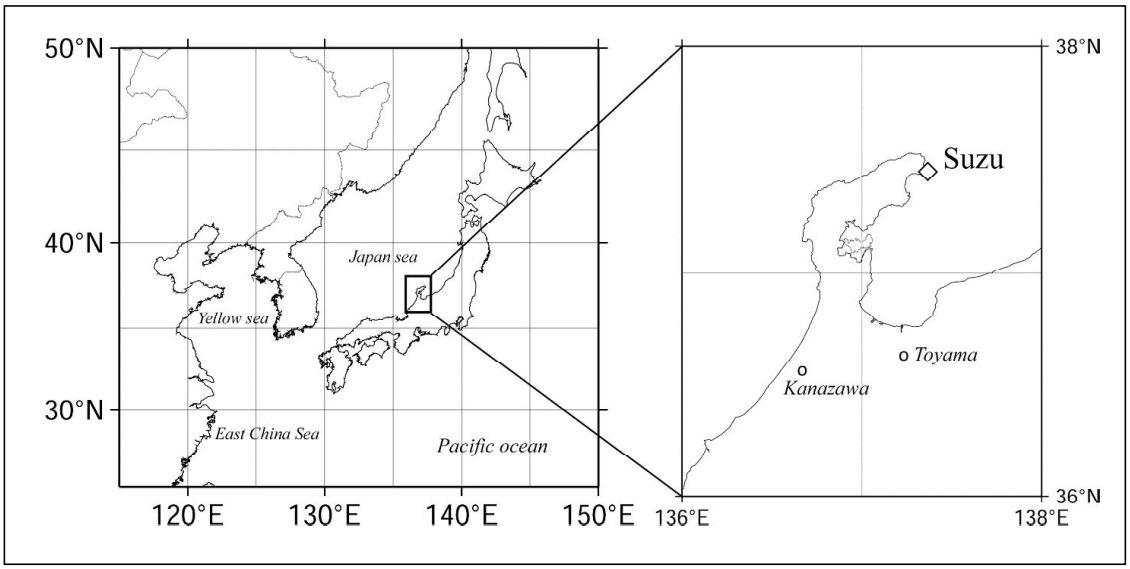

Figure 1. Geographical setting of NOTOGRO station

concentrations ranging over 57.4-89.6 pMC throughout the year (Figure 2). The minimum and maximum ^{14}C concentrations differed by about 30 pMC. When compared against other reported pMC values from urban areas relevant to East Asia, for example 33-48 pMC in Beijing [10], 31-54 pMC in Tokyo [7] and 25-65 pMC in Nagoya [3], our values lie in the upper end, highlighting larger contribution from modern (non fossil) sources. The contrast with Nagoya may be particularly relevant because the city lies almost in the same longitudinal zone (35.15ºN, 136.97ºE) as our remote measurement site but it is one of the major cities along the other side of the main island Japan (i.e. facing the Pacific Ocean).

The strong seasonal variability in the modern and fossil carbon fractions should reflect changes in both the monsoonal wind patterns and emission profiles of multiple sources. In winter, fine aerosol particles surviving the wet and cold winter monsoon showed minimum ^{14}C concentrations which dropped down to 57.4 pMC, indicating largest influence of fossil fuel combustion due to increased demand for domestic heating in the continental cities. In summer in the contrary, long-range transport from the continent became less active. Instead, local to regional sources within Japan gained relative importance. The active photochemistry and resulting SOA (secondary organic aerosols) formation may partly be responsible for the larger modern carbon fractions found around 70 pMC. In spring, the ^{14}C concentration showed a general increasing trend most likely reflecting the end of heating season and mixing of carbon from more diverse sources and air-mass origins.

The maximum ^{14}C concentrations were observed in a sample collected in late July (89.6 pMC), and all of the samples collected in October (83.7-89.5 pMC). These values indicated that the increased carbonaceous aerosols (soot, organics) observed during these events were predominantly of modern origin. Additional chemical analysis of biomass burning tracers, as well as stable carbon isotope strongly linked the former event with a sporadic plume from Siberian forest fire, and latter with the systematic outflow from post-harvest open field burning involving C_4 plants (e.g. maize straws) in northeastern China. To the best of our knowledge, this is the first report to point out the link between the growing maize straw burning practice in the region and its impact on the downwind aerosol composition based on the carbon isotopes.

Wheat and maize straws are the major agricultural residues in China and field burning of such biomass is still a common practice [6]. Although such practice has been banned since the late 90th in relation to deteriorating regional air quality, major changes in the energy structure turned down the demands of the residues as attractive energy sources and facilitated field burning. Such biomass burning is expected to peak with crop harvests. Huang et al. [1] constructed a multi-annual, emission inventory of crop burning in different parts of China based on MODIS fire products. They demonstrated a strong seasonality in the agricultural fire counts in the north eastern China (which coincides with the region in concern), with peaks in spring (March, April, May) and in autumn (October) as well. Interestingly, the inter-annual analysis between 2003-2010 revealed that the second peak in October was hardly visible in the early years, but gradually became prominent in the later years [1], which suggests that the second peak of post-harvest burn in October in this region is a rather new and growing practice which emerged merely over the course of the last decade or so.

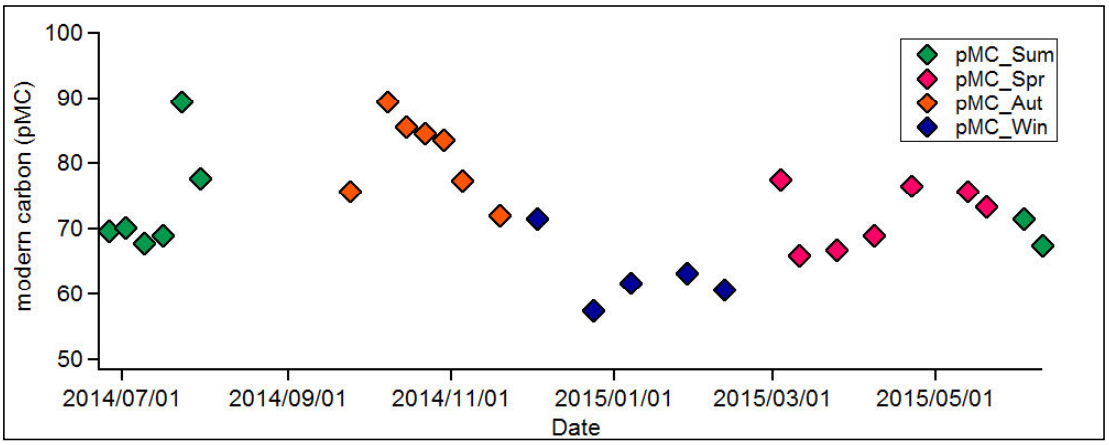

Figure 2. Seasonal variations of ^{14}C concentration found in weekly $PM_{2.5}$ samples collected at Noto peninsula (western coast of central Japan)

Conclusion

This study provided an almost year-round data set of weekly ^{14}C concentrations in the fine-mode carbonaceous aerosols representing remote coastal region in central Japan, where it is often subject to outflow from different parts of the Asian continent. The results revealed relatively high contribution of modern carbon, 70 pMC on yearly average, which can be attributed to primary and secondary emissions from natural biological activity and/or biomass burning (including naturally or human lit fire). This in turn indicated that the fraction of carbon originating from anthropogenic fossil fuel combustion (e.g. coal, oil) accounts for approximately 30% at the background site downwind of East Asia.

The result of this study revealed dynamic seasonality in the relative contribution from modern and fossil carbon sources, and helped narrow down the source of carbonaceous aerosols in the East Asian outflow region. The use of such data can be further extended to constrain complex organic aerosol emission and evolution in East Asia where both anthropogenic and natural sources intricately affect each other. Especially, the geographical setting of our station makes our results more representative of a remote, background area directly under the influence of the East Asian outflow. Comparison with other urban sites will be meaningful to isolate local impacts from what is being transported externally.

Finally, there was a clear increase in organic mass fractions and BC concentrations within fine aerosols during biomass burning episodes despite long distances from the identified sources. It has many important implications in terms of the regional air quality, climate and water cycles. In particular, how much impact these biomass burning plumes have on the cloud nucleating activities of atmospheric aerosols in the downwind regions remains to be resolved.

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GRASSFIRE FORECAST AT AGRICULTURAL LANDS IN JEWISH AUTONOMOUS REGION

Vladimir A. Glagolev*, Anna M. Zubareva, Elena A. Grigorieva
Institute for Complex Analysis of Regional Problems Far Eastern Branch Russian Academy of Sciences (ICARP FEB RAS), Birobidzhan, Russia
Email: glagolev-jar@yandex.ru (*corresponding author)

The method proposed for prediction of the grass fire ignition and development during spring-autumn fire period is based on the author's probability model for prediction of wild fire ignition depending on natural and man-made conditions, and the Australian McArthur model for forecast of non-forest fire development. This method has been verified on fire data of 2015-2017 in the Jewish Autonomous Region. Calculations were done with the help of electronic maps of forest area quarters and the network of operational-territorial units (OTU) of the agricultural lands designed at 2.5 x 2.5 km cells. The Earth's remote sensing data on non-forest fires in 2010-2014 and information on Normalized Difference Vegetation Index (NDVI) during periods before and after growing season (April 23 – May 13, and September 24 – October 10) are used. The highest probability of the fire effect on agricultural land is found at a distance of 3 km from the roads and 3-6 km from the urban areas. The spatial coincidence of OTU with real and predicted grassfires and the validity of the forecast in spring before growing season are considered to be satisfactory. The suggested method of predicting grassfire ignition and development has a considerable practical importance and can be applied in the development of fire-incident management strategies and measures to mitigate a threat to human and environmental health.

***Keywords**: grassfire, ignition and development, Jewish Autonomous Region.*

Introduction

Prognosis and control of grassfires at agricultural land close to the woody plot is important for mitigating its threat to human and environmental health. These fires often cause significant damage to plant ecosystems, being the reason of forest and turf burn. The complexity of their monitoring, prevention and elimination is explained additionally by the fact that these areas are not assigned to the organizations of the Russian State Fire Service, and firefighting is transferred to municipal and private organizations.

Domestic and foreign systems of prediction the ignition and development of fires are based on two approaches: they use mathematical models of analytical type and experimental-statistics. In Russia, presented models are mainly applied to predict the rate of forest fire development, its perimeter and area [1, 5, 9]. The model proposed by McArthur is based on special datasheets of natural conditions in the southeast of Australia, and is most-known model used to predict the development of non-forest fire in grassland [7]. The Ministry of Natural Resources of Canada uses the Fire M3 – Fire simulation and mapping system, which is designed to search active vegetation fires, estimate their area, and transfer data to the Canadian Wildland Fire Information System [6]. The construction and testing of system for predicting the spread of grassfire that cause fire transition onto the woody plot, has not yet been carried out in Russian Federation, and therefore becomes particularly important.

Herbaceous plant fuel depends on features of grass species, and its fire hazard characteristics are based on grass ecology (annual or perennial plant, vegetation period, density, degree of drying, ratio of dead and vegetating grass) as well as on weather conditions that play a decisive role in ignition and spatiotemporal development of fires. The period when grass is ready to burn depends first on the phenological phase of plant, and second, on its gross volume, density, and energy content, and on weather conditions. This is the main difference in predicting grass fire hazard when compare with risk of forest fire.

Germination, spring green up stage and tillering are grass vegetative phases which are very important for agriculture, and affect productivity of natural hayfields and pastures. Coloring and defoliation period (transition of vegetating plant to dry leaves and twigs), and period from leaf coloring stage to seeding time, are the most fire-dangerous phenological phases when highly flammable grass is the main conductor

of burning. The fire has a high rate of distribution and can change direction, overcoming various barriers and spreading to a vast area. Weather conditions affect the degree of drying of vegetating grass and dead twigs. Grasses as a conductor of burning respond to changes in climatic, seasonal and daily weather conditions faster than other species.

All the above characteristics of the herbaceous plant fuel are critical for the assessment of the probability of grassfire ignition on natural and agricultural lands and its development onto the forest areas. In the Jewish Autonomous Region (JAR) the yield from natural grassland (18.7 kg ha^{-1}) is higher than the mean value for Russia (10.0 kg ha^{-1}). Successful progress of livestock farming here depends on the quality of natural hayfields and pastures. That is the reason why grassfire and its prediction in region is an important problem not only for forestry, but for agriculture as well. The current work focuses on design of method for grassfires forecasting in the transition seasons of spring and autumn, which is crucial for monsoon climates at boreal latitudes [4]. This method is based on the author's original model for prediction of forest fire ignition depending on natural and man-made conditions, and the Australian McArthur model of non-forest fire development.

Method and Materials

Our own method for grassfires forecasting includes the following stages: 1) to determine periods of agricultural grassfires; 2) to determine daily level of grass drying during those periods; 3) to calculate daily fire hazard depending on weather conditions that favors the generation of fire, with purpose to identify days when grassfire can ignite due to meteorological conditions; 4) to calculate the probability of grassfire ignition depending on natural and man-made factors; 5) to calculate the rate of grassfire development; 6) to calculate time of probable grassfire spread onto the nearest woody plot.

First, the degree of plant drying at the beginning of the pre-vegetative period and at the end of the post-vegetative period is defined. For this purpose it is assumed, that on a dry day grass is dry with an increased level of dry carbon. Dry day is determined as a period when daily precipitation falls in the range of 0 – less than 3 mm in previous, current and subsequent day. Literature review shows the content of non-forest dry grass (C) is maximum (100%) during the steady temperature transition from 0 to 5°C [3]. In other periods the content of dry grass is defined by Normalized Difference Vegetation Index (NDVI) [8, 10] as −0.5 for artificial materials (concrete, asphalt); −0.25 for water; −0.05 for snow and ice; 0 for clouds; 0.025 for open soil; 0.5–0.7 for sparse vegetation; 0.7–1.0 for dense vegetation. If pixilation of non-forest area is from 0.5 to 0.7, C is equal to 50%; from 0.7 to 1.0, C = 0%.

The prediction of grassfire probability is made on the basis of modified deterministic-probabilistic model by Filkov and Baranovsky [1, 6] (1):

$$F_{i,j}(B)=\begin{cases} F_{i,j}(C)\left[(F_{i,j}(N)F_{i,j}(B/N)+ \right. \\ \left. +F_{i,j}(M)F_{i,j}(B/M) \right] \quad at \quad R_N \le R_{kp} \\ F_{i,j}(C)\left[(F_{i,j}(D)F_{i,j}(B/D)+ \right. \\ \left. +F_{i,j}(M)F_{i,j}(B/M) \right] \quad at \quad R_N > R_{kp} \end{cases}, \quad (1)$$

where i – forecast day; j – operational-territorial unit (OTU) as a pixel at the remote sensing (RS) image; $F_{i,j}(B)$ – probability of grassfire; $F_{i,j}(C)$ – probability of grass burning depending on complex meteorological index [10], determined by the degree of pyrophytic danger; $F_{i,j}(N)$, $F_{i,j}(D)$ – the probability of man-made origin of fire from the nearest settlement, railway or highway; $F_{i,j}(B/N)$, $F_{i,j}(B/D)$ – probability of burning due to man-made reasons; $F_{i,j}(M)$ – probability of natural reason of fire (lightning); $F_{i,j}(B/M)$ – probability of fire due to natural reason of fire (lightning); RN – distance from OTU to the nearest settlement. N, D and M form a complete group of incompatible events, which are calculated as frequency characteristics [2].

The McArthur method (mk4) for meadow areas was used [7] to calculate the rate of grassfire development (2):

$$v = 0.2\,6e^{5.0\,1\lg(c+0.001)-2\,3.6+0.028t-0.226\sqrt{r\,h}+0.633\sqrt{v}}, \quad (2)$$

where w is rate of grassfire (m s^{-1}), rh – air relative humidity (%); c – dry grass content (%), v – wind speed (m s^{-1}).

The calculation of the time for grassfire speeding up to the nearest woody plot is determined by the rate of burning and distance to the forest.

The area of non-forested land in the JAR covers 1382 thousand ha, that is 38% of its total square. 2010 to 2014 year period was taken as a base period for a model; 2015 to 2017 year non-forest fire data were used to verify the model. Calculations were made using specially constructed electronic map of forest area quarters and the network of OTU at the agricultural land designed as 2.5 x 2.5 km cells (Figure 1); total number of cells was 2623. Each cell contained 100 pixels of the Moderate Resolution Imaging Spectroradiometer (MODIS) image with a special resolution of 250 m. MODIS is a sensor onboard the Terra satellite launched by National Aeronautics and Space Administration (NASA) (public access on NASA

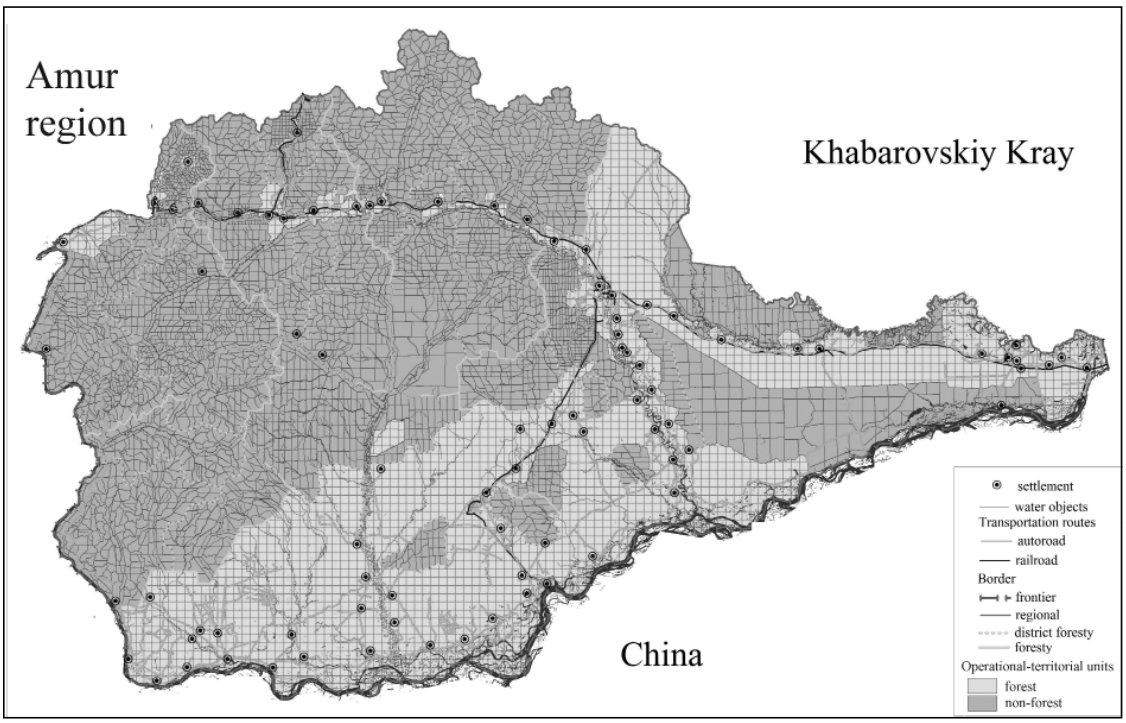

Figure. 1. Electronic map of operational-territorial units, Jewish Autonomous Region

website http://rapidfire.sci.gsfc.nasa.gov). RS data on non-forest fires in 2010–2014 and information on NDVI index before (after) growing season (April 23 – May 13 and September 24 – October 10) were used.

Information on grassfires for period 2010–2014 is based on MODIS data in 36 spectral channels with a spatial resolution 250, 500, 1000 m per pixel. Since land with non-forest fire is only recorded by RS data, the rule of 70–100% non-forest area to the woody area ratio should be applied to classify the land as non-forest area.

For spatial prediction of grassfire and calculation of spreading rate, RS images obtained in red (620–670 nm) and near infrared (841–876 nm) channels (product MOD09GQK) were selected and utilized.

The Student *t*-test with a probability threshold of 0.5–0.6 at level of 0.05 was used to decide the difference or similarity between spatial distribution of OTU with actual and predicted grassfires.

Results and Discussion

NDVI index was calculated pixel by pixel for 12 days out of 30 in spring and autumn; images were not considered in days when clouds covered near 90%. For each OTU of non-forest land, the mean vegetation index was determined by sampling the corresponding values of nested pixels at the satellite image.

Figure 2 presents information on NDVI index for April 27, when 3 fires were detected, and for April 28, with fires spreading to woody plots. Figure 2 shows the probability of grassfire in non-forest area on April 27 and the speed at which these fires run to the woody plots. In most cases, the running time is more than 12 hours depending on wind speed and other weather conditions. On April 27 and during the previous days NDVI was not recorded for clouded areas, which were colored white on the map.

According to *t*-test statistics, there is no significant difference between spatial distribution of the OTU with actual and predicted grassfires in spring, which means that grassfire forecast is considered to be satisfactory. The validity of the forecast in the spring pre-vegetating period is more than 60%; the autumn forecast was not validated due to the small number of fires.

The probability of man-made origin of fire from the nearest settlements or railways and highways was determined for the base period from 2010 to 2014, maximum of grass fires being observed at a distance of 3 km from the roads (2,714 cases) and 3–6 km from the urban areas (918 cases). The results show the grass- and pasture lands in the southern and south-eastern part of the study area are mostly exposed to burning (Figure 3).

As a whole, the consequence of the pyrophytic factor influence depends on the degree of exposure to burning. In areas with frequent fire load they contribute to a reduction of the total number of species of

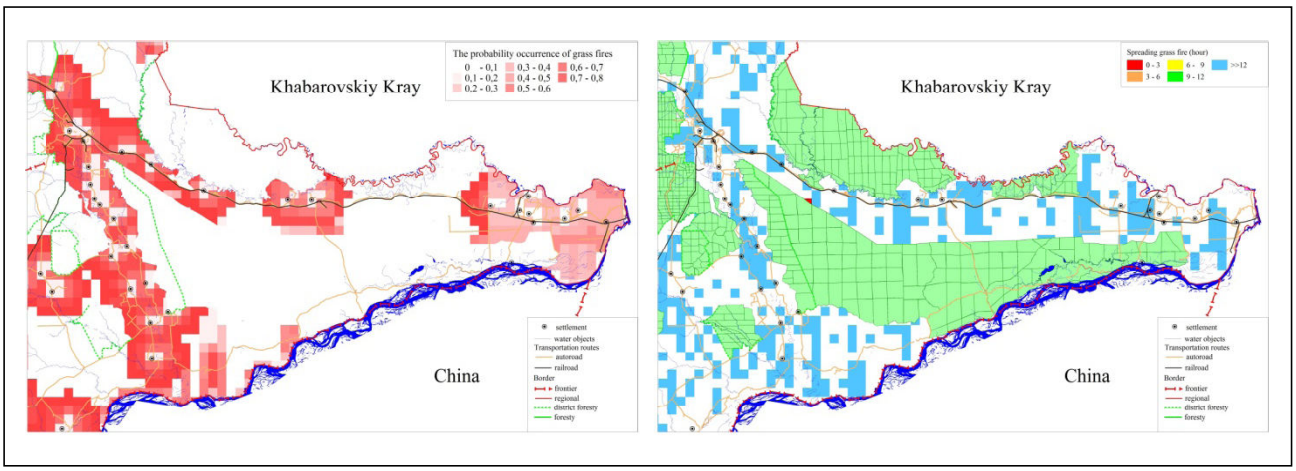

Figure 2. Forecast of grassfires ignition and time to spread onto the woody plots, April 27, 2015, Birobidzhanskoe Forestry in the Jewish Autonomous Region

vascular plants and complete burning of litter layer. On the contrary, non-frequent low fires do not affect underground biomass, the grass community does not deteriorate, species richness does not change, which may strengthen shrub growth. Fire does not cause any serious disturbances and acts as a natural renewal factor for this type of vegetation, playing beneficial role in its permanence.

Conclusion

A method of forecasting the ignition and development of grassfires depending on natural and man-made conditions is proposed. This method is verified on grassfire data from the Jewish Autonomous Region in 2015–2017. The results for spring are found to be satisfactory; verification for autumn is planned as the next step of the research project. In summary, it was found that the high probability of the fire affecting agricultural land is observed at a distance of 3 km from the road network and 3–6 km from the settlement. These areas are mainly concentrated in the southern and south-eastern part of the Jewish Autonomous Region, where the main hayfields and pastures are located. The suggested method is of great practical importance and can be applied for fire-prevention measures and recommendations.

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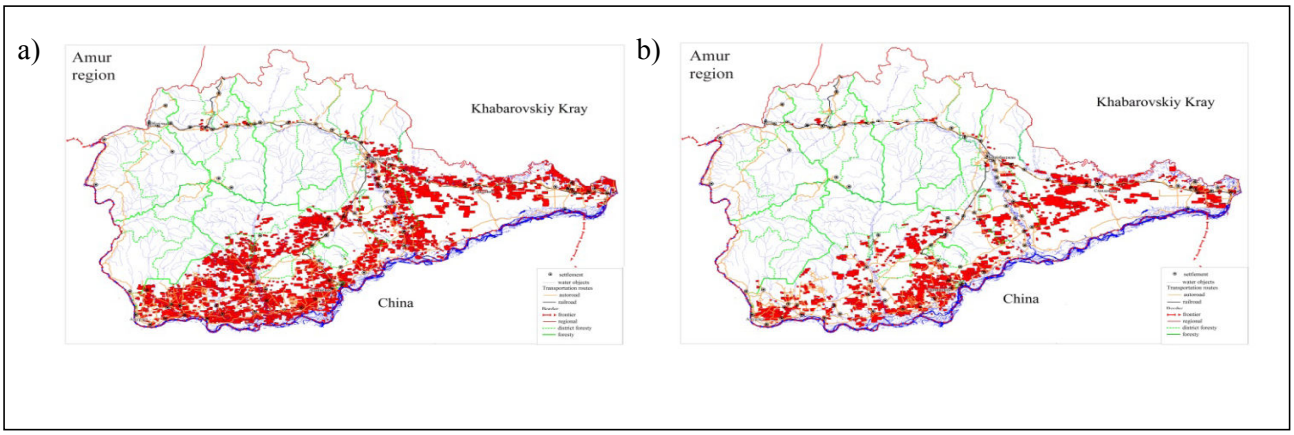

Figure 3. Grassfires in the Jewish Autonomous Region, 2010–2014: a) spring, b) autumn

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CLIMATE CHANGE: CHALLENGES FOR FOOD AND SOCIAL SECURITY

UDK 338.43+551.583

RISK MANAGEMENT IN AGRICULTURE AND ADAPTATION TO THE CLIMATE CHANGE

Tatiana A. Potenko*, Alexey N. Emelianov
Primorskiy Scientific Research Institute of Agriculture (PSRIA), Ussuriysk, Russia
Email: potenko@mail.ru (*corresponding author)

The study examines agricultural risk management policies in Russia and its response to conditions of climate change. Two types of policies are analysed: individual yield insurance triggered by observed yield shocks on the farm and ex post payments triggered by a large systemic shock. The impact of climate change differs depending on the location. For example, the most reliable sources now prove that climate change will increase production risk, measured by yield variability of the main crops in Russia. In the Southern Far East there is evidence that some crops show increased production risk and others show reduced risk. This research provides valuable information of the policies interact with risk management and adaptation strategies, and how to solve the problems of the policy-making under strong uncertainties. There are strong links between risk management and adaptation policies, and government responses to protect farmers from climate change risks that will affect their strategies. For example, support of insurance schemes and of ex post payments may reduce the incentive to diversify farm production giving up production of more climate sensitive crops and farm practices. In this sense these government supported instruments can potentially crowd out appropriate adaptation strategies by farmers.

Keywords: *climate, agriculture, risk, Russian Far East.*

Introduction

Agriculture, due to its origin is inherently sensitive to climatic conditions, and is among the most vulnerable sectors for risks and impacts of global climate change [2, 3]. The agricultural sector of the Russian Far East (FE) shows good results over the last five years, however, the climate cannot be called favourable for full development of agriculture, which is accompanied by many risks.

Extreme weather events repeat quite often, which leads to significant losses for agriculture. Heavy precipitation in the form of heavy rainfall brings serious damage to agricultural crops. At the same time hot and dry weather occasionally takes place, which also negatively effects upon the growth and development of crops. According to the publication of Sigma (Swisre), the trend of rising catastrophic losses and natural disasters is observed in the world. Some experts directly bind this fact to the risk of climate change affecting the economic system, food security, infrastructure, and people well-being. In the mean time the gap between the damage total size and insured losses is increasing [1].

One of the largest in the last 120 years flood in the FE occurred in 2013. It brought massive destruction and made the State to come back to talking about insurance of risks in agriculture. The total flood damage caused to farmers was estimated by the Ministry of Agriculture of Russia more than 80.6 mln dollars. This amount is approximately equal to the entire premiums of the agricultural insurers under contracts with the State for 2013. Farmers of the Far East, most often used to insure crops of soybeans, corn, rice, wheat and vegetables: potatoes, cabbage, sugar beets.

The total area of agricultural land in the Far Eastern Federal District is about 1.68 mln hectares. 37% of the area suffered from floods and only 7% were insured with state support. In the Amur region crops were insured on the area of 39.5 thousand hectares, that was 5% of the cultivated area. In Primorsky Krai they insured 41.1 thousand hectares (11% of the cultivated area), in Yakutia – 10.2 thousand hectares (23.3% of the area). In Khabarovsky Krai, Jewish Autonomous Region and Magadan Region, crop insurance was not conducted. Flooding in 2016 once again made people to talk about the problems with the system approach to the insurance of agricultural risks.

Materials and Methods

Theoretical basis of this article became research works of the scientists who studied the demand and efficiency of different instruments of the policy man-

agement in risks, when agriculture is differently affected by the climatic changes. Studies show that without adaptation, climate change is generally problematic for agricultural production and for agricultural economies and communities; but with adaptation, vulnerability can be reduced and there are numerous opportunities to be realized [2, 3].

While conducting the research the authors used the general economic methods (observation, dialectic, comparative and the system method).

Results and Discussion

The Government programs in agriculture and insurance are institutional responses to the economic risks associated with climate change, and have the potential to influence farm-level risk management strategies. These include government agricultural subsidy and support (to decrease the risk of climate-related income loss, and spread exposure to climate-related risks publicly); private insurance (to decrease the risk of climate-related income loss, and spread exposure to climate-related risks privately); and resource management programs (to decrease the risk of climate-related retirement from agricultural use of agricultural land).

Agricultural subsidy and support programs involve modifications to and investment into established and ad hoc government programs. Ad hoc programs provide compensation for disaster-related income loss independent of the support provided by the established crop insurance, income stabilization and farm production subsidy, support and incentive programs [5]. Ad hoc programs greatly influence farm-level production and management strategies by transferring risk in agriculture [4].

State participation in agricultural insurance is implemented through the provision of subsidies for reimbursement a part of the costs of agricultural producers for the insurance premiums payment on the contracts of insurance [5]. On the basis of the model of the system of State support for agricultural insurance in Russia the principle of co-financing is placed, which provides allocation of funds from the Federal and regional budgets. In subsequent years this system was constantly changed being directed to its improvement, in particular:

- reduced financial burden on agricultural producers in two ways. Firstly, they pay only 50% of the insurance premiums under the insurance contract. Previously they did insurance fee in the amount of 100% of the award and for a long time waited for 50% subsidy. The remaining part of the insurance premium is paid by the authority of the Office of Agriculture of the Russian Federation to the current account of the insurer. Secondly, it is provided to use method of unconditional deductible (participation of the insured in the Risc) ranging from 0 to 40% of the insured amount;

- agricultural insurance with the State support was carried out only against the risk of loss (death) harvest crops, perennials. Here in the loss refers to an actual reduction of crop yield by 30% or more than planned. As for perennials – that means perennial plantings viability loss by more than 40% of the areas.

The objects list of agricultural insurance for crop production and livestock production which are supported by Government, was expanded. They expanded list of dangerous natural phenomena caused the occurrence of the insured event. In addition the list included such phenomena as the dry wind, strong wind, and natural fire. In addition, the list of risks included violation of the electrical supply, thermal energy, and water as a result of natural disasters for the insurance of agricultural crops grown in greenhouses or on the reclamation lands. The agricultural risks insurance with the State support is carried out by insurance companies that are members of the Association of insurers. In the event of bankruptcy of one of the insurers premium is paid from the compensation fund.

In recent years, a number of measures have been taken for the development of this direction, in particular, certain regions have introduced additional support from regional budgets to pay the insurance premium, and farmers compensated for about 90% of the value of the insurance policy.

The development of private insurance represents the climate risk management tool that is primarily the responsibility of the financial services sector, which, in turn, is usually influenced by Government programs. This involves the development of insurance schemes by private companies to recoup crop and property damage from such climate-related hazards as droughts, floods and other climate-related events.

Despite the fact that this risk management tool has the potential to reduce vulnerability at farm level, its implementation in Russia is limited by the availability of existing problems with which farmers have experienced in practice. Among them are: a small amount of weather stations, that eliminates the possibility of obtaining objective information on the occurrence of the adverse factors affecting crop productivity; the criteria system of natural hazards for crops for different climatic zones is not developed.

Floods in the FE showed that crop damage as a result of the flooding is not an insured event (the law provides only risk “water-logging of the soil”). However, the risk of “flood” is included into the list of events for insurance of agricultural animals. Therefore, the definition of the criteria of the most dangerous weather phenomena should be more clearly written down in the law, taking into account climatic charac-

teristics of individual regions of the country. The regulatory framework which helps to settle the losses needs to be improved. The loss settlement process should be standardized, unambiguous in terms of the approach to natural hazards criteria.

They do not ascertain what damages should cover the farmer himself, including through insurance, and in what cases the State should help. It's impossible to insure only part of the acreage. That is, if the agricultural producer grows crops on different plots, each of which is characterized by a certain level of risk, he will have to insure the entire area, regardless of whether it is exposed for risks or not. When agricultural producers operate in the conditions of the funds shortage, a small part of them will agree to insure the area with a low probability of risk. As a result, insurance companies do not often want to insure agricultural crops, especially the risky territory. Only 7 out of 256 insurance companies in the Far Eastern Federal District insure agricultural risks under contracts with the State support.

Adoption of the Law on Single Subsidy in January 2017 contributed to the reduction of insurance of risks in agriculture. A single subsidy mechanism allows regions to spend the subsidy for the State support permitted by the law. The regions used to refuse the subsidy for crop insurance, and began to allocate funds of the State support for agricultural insurance for other purposes. There are 28 territories in the Russian Federation with a high level of weather risk for harvest; 15 regions of this group are not planning support for the insuring in 2018. Especially harmfully it effected upon insurance risks in crop production, where the insured with the State support area, as a whole in Russia, decreased from 4.1 to 1.3 million hectares in 2016. For example, in Primorsky Krai, the number of contracts on insurance of crop yield in 2017 decreased more than 2.5 times, from 306 to 112. As for the crop insurance with the State support it decreased almost six times, to 26.

Conclusion

Insurance of agrarian sector of economy is one of the most complex and expensive insurance products, as in Russia, many regions belong to the zone of risky agriculture. However, as the World practice shows, it is the most reliable way to protect farmers from large financial losses. That is why in many countries insurance is the only type of insurance in which the state participates directly. This factor is important to take into account when establishing priorities of the national agricultural policy. To make efficient use of the planned resources, it is necessary to improve constantly the conditions of agricultural insurance, and procedure for the State support. It will contribute to the expansion of agricultural insurance and will bring more complete compensation for the loss of farmers through insurance mechanism.

It is important to pay attention to the following aspect. When Russia joined the World Trade Organization, they succeed on a high level to get support for our agricultural sector of $9 billion/year. Some experts suggested that the Russian budget is unlikely to be able to find the money allowed by WTO for the support of domestic agricultural sector. But no matter how the situation with the State support develops, its level, according to the signed Agreement, will permanently reduce until 2018. Under these circumstances, subsidies for agricultural insurance is not only a source for its expansion (WTO rules do not contain any restrictions on the subsidies for insurance), but is also an important contribution of the State into rural development at all.

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ENVIRONMENTAL MIGRATION: ESSENCE, PROBLEMS AND POSSIBLE SOLUTIONS

Orozonova Azyk
Institute of Economics named after academician J. Alyshbaev,
National Academy of Sciences of the Kyrgyz Republic, Bishkek, Kyrgyz Republic
Email: azyk.orozonova@gmail.com

Climate change, desertification, high risks of water supplies and increasing droughts in irrigation networks of rivers and canals (Karakalpakia, Aral); ethnic and linguistic barriers between titular nation and small nations (Kazakhs, Karakalpaks) in Uzbekistan, which hampers their internal migration and threatens assimilation within the country – all these reasons are not a survival strategy, but contribute to escape in search of asylum to other territories (Russia, Kazakhstan). There is a need to address the problem of environmental migration, therefore, the concept of an "environmental migrant", an "environmental refugee" should be introduced into practice. Why is environmental migration as a problem requiring detailed study? This is a complex process, which has the same characteristics with a general migration of the population, but which has its own characteristics. An analysis of this process shows that, despite the obvious relevance and significance, the problems associated with it remain unresolved. Theoretical development of migration policy is interdisciplinary, therefore, political scientists, sociologists, lawyers, demographers, historians, psychologists are engaged in migration issues. The interdisciplinary approach will reveal the economic, political, ecological, psychological aspects of environmental migration will give an objective assessment of its condition, will identify the main areas of improvement in the field of right regulation, socio-psychological adaptation in migrant resettlement areas.

***Keywords**: Environmental refugee, environmental migrant, situation of asylum search.*

Introduction

Why is environmental migration as a problem requiring detailed study from the general structure of population migration? This is a complex process with the defining one and the same sign, but different in features. An analysis of this process shows that despite the obvious relevance and significance, the problems associated with these processes remain unresolved. The theoretical development of migration policy is interdisciplinary, therefore, political scientists, sociologists, lawyers, demographers, historians, psychologists are engaged in migration issues. The interdisciplinary approach will reveal the economic, political, ecological, psychological aspects; allow giving an objective assessment of its condition, identifying the main areas of improvement in the field of right regulation, social and psychological adaptation in the places of their resettlement. The relevance of studying environmental migration as a special kind of population displacement caused by natural disasters is difficult to predict.

Environmental migration caused by natural disasters, hazards, etc. and their consequences have been little studied, there are no statistical data and results of sociological research. Earthquakes, floods, drought, forest fires take lives of people. There are many crippled destinies of people – environmental refugees, migrants who were endangered by natural disasters, tragedies of Aral, Semipalatinsk, Chernobyl, Chelyabinsk, flood in Yakutia, volcanic eruptions, explosions in mines caused by technogenic processes are known. This is not a complete list of what is happening only in the territory of the post-Soviet space. The alarm today is caused by flooding of the territory of Great Britain, Holland, climate change in Eastern Europe. And this requires a joint study and development of a new approach to environmental migration. Where these people go, how their fates are formed. How do they live in a new environment, how are they called: refugees, illegal immigrants, migrants, etc. How is their status determined? The report of the Global Commission on International Migration has developed new categories of migrants, such as "environmental migrants" – people who were forced to relocate due to environmental disasters and "forced migrants" – those who were forced to move to their country of citizenship as a result of circumstances endangering their life.

Environmental migration – problems and solutions

The materials on the migration problems of international organizations do not pay enough attention

to the individual assessment of the status of residents affected by disasters and hazards, limited to conducting seminars and collecting information on them. The recommendations do not reflect the ways of solving migration problems. The forced relocation of people from Karakalpakstan to Kazakhstan requires a differentiated approach to them. The identification of this category of "environmental migrants" from among other migrants returning to their historical homeland has prompted, first of all, the preservation of the life and health of children.

The absence of forms and methods of relocation from the disasters and hazards zone does not provide a real system for tracking environmental migrants. These events will periodically arise, causing serious changes in the stability of people. Are we ready to withstand to forces of nature? The task is to use the real possibilities of survival in these conditions with the least losses. The relevance of studying environmental migration as a special kind of population displacement caused by natural disasters is difficult to predict. Any state needs to take into account natural disasters. In the early 1990s, the President of Kazakhstan, N.A. Nazarbayev appealed to the Kazakhs living outside to return to their historical homeland. Resettlement programs in Kazakhstan in the early 1990s were actually implemented within the framework of the law "On migration". After the collapse of the USSR, the law played a huge role in resettling and settling in a new place many people who came from far and near abroad. Annually, the Presidential Decree allocates a quota of immigration, which involves the allocation of funds for the number of families that have arrived. Migration programs are of a general nature, they are not supported by enforcement mechanisms, which allows migrant service executives to implement them in accordance with their perception of the benefits. Measures taken at the governmental level leave migration uncontrolled, not predictably influencing the socioeconomic situation of the republic. The proposed scientific developments, recommendations and proposals do not find practical application.

Impoverishment of a separate part of environmental migrants, unemployment without housing, and inaccessibility to loans causes a natural protest from migrants, as evidenced by the events of Shanyrak city of Almaty. It is a constant hotbed of tension and social conflict within one nationality, and not an interethnic conflict and is not always taken into account by state bodies. The first resettlement associations emerged, whose main goal was to confront bureaucracy and uphold minimal economic and social rights. In the changed conditions, the focus of migration policy shifted from the problems of environmental migration to the problems of economic migration. Migration losses exceed the natural increase in population.

Shallowing of the Aral Sea in the delta of the Amu Darya has led to a sharp deterioration of the ecological situation, desertification and salinization of soils, which really threatens the health of the population living in this area. There was a hope turning a part of the runoff of the Siberian Rivers, which is nowhere. But how much money was invested in research? This factor forced many people to legally and illegally migrate to more prosperous places, primarily to Kazakhstan and Russia. Over the past fifteen years, more than 450,000 people, mainly ethnic Kazakhs, have moved from the Uzbek part of the Aral Sea to Kyrgyz republic. And this process has acquired a massive, landslide character, which cannot be accounted for and controlled. The deterioration of the ecological situation leads to economic losses and a decline in the standard of living. The process of land development, the pursuit of a high yield led to irreversible processes.

The situation is exacerbated by the lack and terrifying quality of drinking water. As is known, the shallowing of the Aral Sea in the Amu Darya delta has led to a sharp deterioration in the ecological situation, desertification, salinization of the soil and poses a serious threat to the lives of people inhabiting the territory. Lack of drinking water and poor quality increased the risk of morbidity in the population. There have been changes in climatic conditions. A significant part of these people, not finding an opportunity for not just a decent life, but also survival in their country, were forced to legally and illegally migrate to more prosperous places, primarily in the territory of the Republic of Kazakhstan and the Russian Federation.

Despite the generally accepted opinion that there is a water deficit in this region, in fact most of the problems are caused by an overabundance of water. Old methods of irrigation require the presence of artificial reservoirs, where "excess" water flows from the canals. 90 percent of the channels are not lined with waterproof material. Watering crops is carried out simply by flooding the fields. All this led to an increase in the level of groundwater, which transport salts to the soil surface and salinize these soils. Saline soil requires washing with fresh water, drainage water after rinsing flows mainly to other water bodies around the fields. The vicious circle closes. The Aral Sea has moved to the upper and middle reaches of the Amudarya and Syr Darya rivers and is located here in the form of tens of thousands of artificial reservoirs

of various sizes. Such a movement of huge masses of water caused local climate change. The number of landslides and mudflows in the mountains increased, rains began to rain more often in winter, and dust storms became more frequent. Dimensions of glaciers of the Pamir and Tien Shan are decreasing. There is a real shortage of fresh water in Central Asia.

Humanitarian assistance

The activities of the International Fund for Saving the Aral Sea are focused mainly on the Kyzylorda region of Kazakhstan and as a whole did not meet the expectations of the population for improving the life of the population of the Uzbek part of the Aral Sea. The allocated funds from international organizations to improve the drainage system in Nukus have not improved the quality of drinking water. Restoring the Aral Sea is a long and expensive process. It is time to save the lives of people living in the Aral Sea region, and there are about 900 thousand of them. These are, in general, the main factors and trends in the process of migration of the population from the ecologically extremely unsuccessful region of the Uzbek zone of the Aral Sea to Kazakhstan. Restoration of the southern part of the Aral Sea is a long and expensive process. It is time to save the lives of people living in this territory, and there are more than a million people who are forced to relocate while saving their lives and their descendants. Environmental migration is one of the most important factors in the migration of the population of the Aral Sea area. Where to go, who is waiting for them? Making sure that the Aral no longer saved, decided to save people.

Environmental migrants faced a number of problems, and first of all, with the lack of their rights, a sense of abandonment and uselessness, many families, mostly families, needed social and psychological adaptation. There is a need to organize such a public organization where they could obtain the necessary information. This flow should be separated from the general flow of Kazakhs from Mongolia, China, Turkey, Iran, etc., their reception, adaptation and arrangement. All this fell on the shoulders of the small organization of the Public Foundation "Center for Support of Environmental Migrants of Uzbekistan". This gap can be compensated by the allocation of funds and legal authority to work with environmental migrants. Without a clear vertical system, this problem cannot be resolved at the level of a public organization. Many ministries deal with migrants, but so far no programs have been developed for their social adaptation, and educational work.

Conclusion

In this regard, it seems essential: – inclusion of the definition of "environmental migrant" – people forced to move beyond, because of "ecological thunderstorms of life and health, due to disasters and catastrophes" into the law on migration; – conducting a real, comprehensive republican study on environmental migrants, with the task of developing a national migration program; – on the basis of the conducted research, to develop mechanisms for implementing the program and for monitoring by public organizations for its implementation, including training programs for specialists in the social and psychological profile in the field of migration; – improvement of the work of state structures with the inclusion of the Ministry of Emergencies involved in environmental migration, organized resettlement and compact resettlement, taking into account the mentality and psychology of people who historically live in difficult times with their community.

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ETHICS: ENSURING FOOD SECURITY IN THE ERA OF CLIMATE CHANGE

Zabta K. Shinwari
Qarshi University, Pakistan Academy of Science and & NCT, Lahore, Pakistan
Email: Shinwari@qau.edu.pk, shinwari2008@gmail.com

The present research covers topics such as global policy options for food security; and existing policy frameworks by the government of Pakistan and national bodies or organizations working for the cause of biosafety, biosecurity in the country. The ethical need to establish effective strategies related to country's preparedness to tackle issues like climate change, poverty and food security is emphasized.

Keywords: *ethics, food security, climate change.*

Introduction

To make it prosper, Pakistan has to work on three major areas: innovation, agriculture and industry. Biotechnology based innovations play an important role in sustainable economic growth. Cutting edge biotechnologies can be used both for the good of humanity and/or for the hostile applications which raises the Dual Use Research Concerns (DURC) about Biotechnology. However, unprecedented increase in population of developing countries like Pakistan needs some kind of "Gene Revolution" to cater the need of the society. Pakistan's altitude ranges from 0 to 8611 m, and is blessed with splendid mountain ranges (Hindu-Kush, Himalayas), vast deserts and forests, numerous climatic zones, all contributing to a fascinating and unique biodiversity, yet the country faces numerous issues including food security.

Decline of biodiversity in developing country is another major issue which will result in reduction of basic ecosystem services. Rich biodiversity areas serve as a major source pool of pathogens. Scientists agree that the loss of biodiversity increase infectious disease transmission among human, animals and plants.

Pakistan has progressed significantly in the different disciplines of life sciences evidenced by the doubling of HEI's, research publications, PhD enrollments etc. Over the past few years. Some of the bioterrorism events has raised alarms for regulating various life sciences technologies. Considering the recent progress in biotechnology, and the potential of DURC, tighter regulations are needed to prevent any misuse. For a country like Pakistan, where the major chunk of economy and GDP comes from agricultural resources, bioterrorism can be a serious threat. An event could bring a serious negative impact on the agro based economy. Therefore agricultural biosecurity becomes fundamental for the country to progress. Benign research in the life sciences has massive potential to be misused, either intentionally or unintentionally. The rapid growth in biotechnology in recent years has offered great benefits globally, but as one of the most rapidly-growing areas of science in the early 21st century, it brings security risks that must be recognized and addressed effectively. Internationally there is an increased interest in the concept of biosecurity at the state and inter-state level, it is yet to manifest in significant activity at the level of the practicing life scientist. Rather, activity on the ground remains limited with many in the life science community perceiving this as an irrelevant or less relevant topic. It is noteworthy to mention the premier role of Pakistan against terrorism on national and global fronts. Therefore, one cannot ignore the bioterrorism threats to the country which is already actively dealing with conventional forms of terrorism.

To address such issues we have to analyze global as well national policy systems including Sustainable Development Goals (SDGs) and organizations like Pakistan Academy of Sciences. Research organizations should work on the issues through research, partnership, and training. This will help in achieving sustainable increases in agricultural productivity and its nutritional quality ultimately leading to better income to the people.

To meet these challenges, the organizations have to play its due role by emphasizing on quality manpower, scientific infrastructure, and cost-effective research. Towards this end, the Government needs to ensure an environment conducive to innovation, ear-

ly stage support system, and investment incentives. The Researchers have also to bridge the gap between researchers, policy makers and agro-based industrial sector through change managers, technological advancement and by encouraging entrepreneurial culture.

Unfortunately, the policy response to food security issues has not been in line with natural resource management. Efforts made so far have been focused on increasing productivity through genetically-modified crops, extensive use of fertilizers and pesticides, and by increasing cultivable land. All these efforts and inputs have adversely affected the agro-biodiversity and degraded the ecosystems.

Scientists prefer only the glamorous aspects of science like Biotechnology or Nanotechnology and they are seldom exposed to the'reality' of rural areas. The real issue is: how does science cater to the poor? We have to look for options as to how the technology could be applied in less fanciful ways to benefit the planet: to produce heat-tolerant coral reefs, pollution-sensing soil microbes. The present work covers topics such as global policy options for food security; and existing policy frameworks by the government of Pakistan and national bodies or organizations working for the cause of biosafety, biosecurity in the country. The ethical need to establish effective strategies related to country's preparedness to tackle issues like climate change, poverty and food security is emphasized.

"Green" and "Evergreen Revolution" concepts

In early green revolution period (1960–1980) Pakistan increased the agriculture trade up to 4.3% per year. In this period some new high yielding dwarf and semi-dwarf varieties of wheat rice and other major crops were produced that showed better performance in the extreme environmental conditions. The resulted varieties showed better growth in the extreme high temperature areas of Baluchistan and Sindh. The wheat yield has increased from 7.7 billion rupees in 1959–1960 to 15.5 billion rupees in 1969–1970. The poverty rate decreased several fold in this period. After that the green revolution undergoes decline condition due to resource degradation, uses of poor conventional farming techniques and lack of proper policy and its implementation for sustainable agriculture.

It is expecting that the rise of country population will be from 20.7 million in 2018 to 240 million by the year 2035. The "green revolution" concept has changed to "evergreen revolution" by combing the molecular plant breeding with the modern biotechnologies. The availability of food and optimum nutrients amount is not possible with conventional techniques. So, the new genetically engineering methods were used to produce more genetically modified products in country. The evergreen revolution era brought many benefits in food sector. Scientists from diverse fields worked in collaboration, and developed multiple genetically engineered crops against biotic and abiotic stresses and for other multiple purposes.

Genetically modified (GM) crops in Pakistan: benefits or threats to food security

Currently Pakistan is ranked seventh in *Bt* crop growing countries and total of 2.9 mha land of country is under cultivation of *Bt* crops. The biosafety commission of Pakistan had approved 32 *Bt* cotton varieties and 119 genotypes are under evaluation step. These varieties are used against a single insect resistance or used as stacked trait (multiple traits). Some varieties showed resistance against broad range of insects and viruses. The *Bt* cotton varieties showed better yield in all four provinces of Pakistan. The *Bt* cotton was very famous among the farmers and cultivated about 97% of cotton cultivated areas. Currently Pakistan has developed *Bt* maize crop against herbicide resistance and grown about 1.2 mha, that produced approx 5 m tons of maize. Several others genetically modified (GM) crops like tomato, wheat, rice, maize has been produced against heat, drought and salinity stresses. The commercialization of these crops and poor consumer response are the two major problems to GM crops. Now Pakistani scientists started working for developing new golden rice varieties, to minimize the blindness problems in children's with no or minimal deficiency of Vit A.

These genetically engineered products are no doubt, hold promise as a means to provide maximum benefits to all living organisms. As the time went on, various social, political, environmental and technical issues related to these technologies took their birth in country. These technologies have produced many problems especially in food security, environmental safety, effects on both targeted and non targeted organisms, use of toxic selectable marker genes, cross pathogens resistance, etc. It can affect non-GM crop by horizontal gene transfer mechanism and disturb its morpho-biochemical and physiological processes. The development of genetic engineering and bioscience technologies also raised of production of toxic pathogens that could directly affect the agriculture sector of any country especially Pakistan. The economic growth of Pakistan is correlated with agriculture, and it fulfills 20% of our GDP. If such new types of toxic mutant virus/pathogen comes to our environment so they could badly affect our agriculture

and other living organisms including human being. Some people believe that these GM crops may fail to resist altered climatic conditions; the food security threat might be increased. The other public concern is if GM crops fail to resist altered climatic conditions; the food security threat might be increased. The other major public concern is that it may loss of seed variety and diversity. So there is a need to develop some new modified GM crop being no ethical or the marker issue. So, it will be useful if we develop some marker free transgenic *Bt* crop in country against multiple purposes.

The developed world has developed some new transgenic plants against change of climate conditions by using novel genetic engineered technique CRISPR (clustered, regularly interspaced, short palindromic repeat) /Cas (CRISPR-associated protein). The CRISPR/Cas9 is a user-friendly system for the production of transgenic plants with counteracting harmful effects from climate change and ensures future food security for increasing population in Pakistan. However, CRISPR/Cas9 technology is not significantly used in Pakistan for further genetic modification in several important tropical plants against both biotic and abiotic stresses, for the yield and quality improvements.

Agriculture and climate change in Pakistan: problems and solutions

Wheat, rice, maize, sugarcane and cotton are the major crops of Pakistan that contribute 23.85 % of the value added in overall agriculture and 4.66% of GDP. The other minor crops contribute 2.15% of overall GDP. The change in climate condition of Pakistan receives negative impact on country economy; more adversely affecting the growth and production of both major and minor crops. In areas where the only source of irrigation is rain water, high temperature and low rainfall are serious threats to crop adaptation. Northern and Southern regions of Khyber Pakhtunkhwa (KP) are drastically effected due to negative impact of extreme temperature and precipitation conditions in Punjab, Pakistan during 2015–2016. As a result decrease in production was found in these major crops i.e. wheat 1.9%, maize 5% and sugarcane 8%. The 5.71 % and 15.26 %, reduction in crop production was observed due to increase in precipitation (during September-October) by 5% and 15% respectively. The affect of elevated temperature was found more severe than precipitation.

The lack of proper policy, management, inter-disciplinary team work, research-practice, and science-policy are some gaps that affect country food security. The other major problem is the uncertainties and not knowing about the future climates. So, there is a need to follow certain modern culture practices to minimize the challenges to food security. There is need to adopt coping strategies like to change crop sowing date with respect seasonal variations, change in harvesting dates, used of short duration genotypes, cultivation of adopted heat and drought tolerant varieties, change in fertilizer practices, change in cropping pattern, etc. It is also important to copy some of the novel strategies used in neighboring countries like India, Bangladesh and Afghanistan having almost same climate conditions. All these strategies may minimize the negative effects of climate change on crop adaptation. The miss-regulation regarding the import and export of major crops need to be controlled. In the past the trader mafia including the ministers and others parliamentarians exported maximum wheat crop for own benefits, not for consumers benefit. In 2018 sugar mills mafia including high influential politicians has become curse for the millions of poor sugarcane growers of the country. So, it is the responsibilities of government to take strict action against these mafias and to raise the income of small farmers to enhance agriculture growth in country.

The natural disaster and military operations in Pakistan affected the agriculture production and balanced food supply to the people. The 2010 floods in Pakistan affected about 4.5 mln people, two-thirds of whom were from agriculture sector. Massive number of farmers lost their land and their expected income. Many people died due to unavailability of balanced nutrients uptake, and majority of them were children. The military operation against "Tehrek Taliban Pakistan (TTP)" started in 2009. About three mln people were affected from this operation. Majority of poor people were from Malakand agency, Khyber Pakhtunkhwa (KP) and from the Federally Administered Tribal Areas (FATA) which left their homes and villages due to security reasons. In these aforementioned areas, agricultural practices are the main source of livelihood. Their cultivated lands, fruit gardens of peach, apricot, date palm, orange were highly affected. Majority of their livestock died due lack of food supply. Ultimately, the quantity and quality of food consumption reduced, and food insecurity and malnutrition increase, particularly among the most vulnerable households. These pressures reduce households' purchasing capacity, restrict access to food, deplete savings, force the sale of vital productive assets and erode livelihoods. Majority of internally displaced persons (IDPs) have started returning home, yet they continue to struggle to obtain food. After winning the operation and by defeat of Taliban, the situation is now totally controlled. But the affected areas still

need more support to the poor farmers from both government and other private agencies. There is a need to raise awareness in peoples of Pakistan where natural disaster, terrorism and food security are some major problems. The changing climate has caused tremendous floods over the past years in Pakistan, hampering the agriculture and food productivity. A good policy regarding changing climate and water storage can go a ling way in Pakistan for achieving the food security.

Pakistan has rich diversity of plants, weather, rocks, soil conditions and water resources. The country progressed in last few decades in agriculture sector. But still it is important to use the modern technologies to promote evergreen revolution in country to promote the yield and overall production of both major and minor crops. Strict biosafety regulation needs to be set up in country to promote the safe use of GM crop with no social, cultural, environmental and socio-economic issues. The private sectors should work in all areas of seed testing, production, multiplication, processing and to promote value addition livestock industry and diversification of livestock products. Transformations are needed if Pakistan is to remove the ills of planning and mental corruption that have seeped into the system. The disaster risk management policies need to be introduced to face the disaster due to change in environmental condition. But still more than one-forth people of Pakistan are living below the poverty line. More dams' construction and modern irrigation systems need to be adopted to face water shortage problem. So, it is the responsibility of individual, government, non-governmental organization and policy makers to choke a coherent strategy to deal with the food security issues in the country, which is already facing complicated issues of terrorism, natural disasters, global warming, climate changes and others like corruption and poverty.

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INTERNATIONAL INSTRUMENTS IN THE FIELD OF CLIMATE CHANGE

Gulzar Karybekova
Institute of Philosophy and Political – Legal researches,
National Academy of Sciences of the Kyrgyz Republic (NAS KR), Bishkek, Kyrgyz Republic
Email: gulzar_80@mail.ru

One of the important international treaties in the field of climate change is the United Nations Framework Convention on Climate Change (UNFCCC). Main objective of the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. At present 165 countries joined to UNFCCC and get good experience in climate change issue and singed a lot of agreements as a Kyoto Protocol, Paris Agreement, Bali Action Plan, etc. The parties to the convention have met annually from 1995 in Conferences of the Parties (COP) to assess progress in dealing with climate change. In 1997, the Kyoto Protocol was concluded and established legally binding obligations for developed countries to reduce their greenhouse gas emissions in the period 2008–2012. The 2010 United Nations Climate Change Conference produced an agreement stating that future global warming should be limited to below 2.0°C (3.6°F) relative to the pre-industrial level. The Protocol was amended in 2012 to encompass the period 2013–2020 in the Doha Amendment, which as of December 2015 had not entered into force. In 2015 the Paris Agreement was adopted, governing emission reductions from 2020 on through commitments of countries in ambitious Nationally Determined Contributions. The Paris Agreement entered into force on 4 November 2016. The aim of the current work is to give a brief review of agreements signed by the UNFCCC.

Keywords*: convention, agreement, climate, change, countries, greenhouse gas.*

Introduction

United Nations Framework Convention on Climate Change (UNFCCC) is one of the important international treaties in the field of climate change. This international treaty is adopted on 9 May 1992 and opened for signature at the Earth Summit in Rio de Janeiro from 3 to 14 June 1992. Main objective of the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system [1]. The framework sets non-binding limits on greenhouse gas emissions for individual countries and contains no enforcement mechanisms. Instead, the framework outlines how specific international treaties called “protocols” or “agreements” may be negotiated to specify further action towards the objective of the UNFCCC. At present, 165 countries joined to UNFCCC and get good experience in climate change issue and singed a lot of agreements as a Kyoto Protocol, Paris Agreement, Bali Action Plan, etc. The aim of the current work is to give a brief review of conferences of the paries and agreements signed by the UNFCCC.

Conferences of the Parties and Agreements signed

The parties to the convention have met annually from 1995 in Conferences of the Parties (COP) to assess progress in dealing with climate change. In 1997, the Kyoto Protocol was concluded and established legally binding obligations for developed countries to reduce their greenhouse gas emissions in the period 2008–2012 [24]. The 2010 United Nations Climate Change Conference produced an agreement stating that future global warming should be limited to below 2.0°C (3.6°F) relative to the pre-industrial level [14]. The Protocol was amended in 2012 to encompass the period 2013–2020 in the Doha Amendment, which as of December 2015 had not entered into force. In 2015 the Paris Agreement was adopted, governing emission reductions from 2020 on through commitments of countries in ambitious Nationally Determined Contributions. The Paris Agreement entered into force on 4 November 2016.

One of the first tasks set by the UNFCCC was for signatory nations to establish national greenhouse gas inventories of greenhouse gas (GHG) emissions and removals, which were used to create the 1990 benchmark levels for accession of Annex I countries to the Kyoto Protocol and for the commitment of those countries to GHG reductions. Updated inventories must be submitted annually by Annex I countries.

According to the Article 3(1) of the Convention [16] states that Parties should act to protect the climate system on the basis of “common but differentiated responsibilities”, and that developed country

Parties should "take the lead" in addressing climate change. Under Article 4, all Parties make general commitments to address climate change through, for example, climate change through, and for example, climate change mitigation and adapting to the eventual impacts of climate change [17]. Article 4(7): the extent to which developing country Parties will effectively their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology and will take fully into account that economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties.

The Framework Convention specifies the aim of developed (Annex 1) Parties stabilizing their greenhouse gas emissions (carbon dioxide and other anthropogenic greenhouse gases not regulated under the Montreal Protocol) at 1990 levels, by the year 2000.

After the signing of the UNFCCC treaty, Parties to the UNFCCC have met at conferences ("Conferences of the Parties" – COPs) to discuss how to achieve the treaty's aims. At the 1st Conference of the Parties (COP-1), Parties decided that the aim of Annex I Parties stabilizing their emissions at 1990 levels by the year 2000 was "not adequate" [10] and further discussions at later conferences led to the Kyoto Protocol. The Kyoto Protocol sets emissions targets for developed countries which are binding under international law.

The Kyoto Protocol has had two commitment periods, the first of which lasted from 2008–2012. The second one runs from 2013–2020 and is based on the Doha Amendment to the Protocol, which has not entered into force.

Kyoto Protocol was not ratified by the US and Canada denounced it in 2012. All the other Annex I Parties ratified the Kyoto Protocol. All Annex I Parties, excluding the US, have participated in the 1st Kyoto commitment period. 37 Annex I countries and the EU have agreed to second-round Kyoto targets. These countries are Australia, all members of the European Union, Belarus, Croatia, Iceland, Kazakhstan, Norway, Switzerland, and Ukraine [13]. Belarus, Kazakhstan and Ukraine have stated that they may withdraw from the Protocol or not put into legal force the Amendment with second round targets [2]. Japan, New Zealand, and Russia have participated in Kyoto's first-round but have not taken on new targets in the second commitment period. Other developed countries without second-round targets are Canada (which withdrew from the Kyoto Protocol in 2012) [15] and the United States.

In 2011, parties adopted the "Durban Platform for Enhanced Action" [9]. As part of the Durban Platform, parties have agreed to "develop a protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties". At Durban [3] and Doha [4], parties noted "with grave concern" that current efforts to hold global warming to below 2 or 1.5°C relative to the pre-industrial level appear inadequate.

In 2015, all parties to the convention came together for the UN Climate Change Conference in Paris 30 November – 12 December and adopted by consensus the Paris Agreement, aimed at limiting global warming to less than two degrees Celsius, and pursue efforts to limit the rise to 1.5 degrees Celsius [5]. The Paris Agreement entered into force on November 4, 2016.

In addition to the Kyoto Protocol (and its amendment) and the Paris Agreement, parties to the Convention have agreed to further commitments during UNFCCC Conferences of the Parties. These include the Bali Action Plan [6], the Copenhagen Accord [7], the Cancún agreements [8], and the Durban Platform for Enhanced Action [2009].

Bali Action Plan. As part of the Bali Action Plan, adopted in 2007, all developed country Parties have agreed to "quantified emission limitation and reduction objectives, while ensuring the comparability of efforts among them, taking into account differences in their national circumstances" [11]. Developing country Parties agreed to "(nationally) appropriate mitigation actions (NAMAs) context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner" [12]. 42 developed countries have submitted mitigation targets to the UNFCCC secretariat, as have 57 developing countries and the African Group (a group of countries within the UN).

Copenhagen Accord and Cancún agreements. As a part of the 2009 Copenhagen negotiations, a number of countries produced the Copenhagen Accord. The Accord states that global warming should be limited to below 2.0°C (3.6°F). This may be strengthened in 2015 with a target to limit warming to below 1.5°C. The Accord does not specify what the baseline is for these temperature targets (e.g., relative to pre-industrial or 1990 temperatures). According to the UNFCCC, these targets are relative to pre-industrial temperatures [18].

114 countries agreed to the Accord. The UN-

FCCC secretariat notes that "Some Parties stated in their communications to the secretariat specific understandings on the nature of the Accord and related matters, based on which they have agreed to (the Accord)". The Accord was not formally adopted by the Conference of the Parties. Instead, the COP "took note of the Copenhagen Accord".

As part of the Accord, 17 developed country Parties and the EU-27 have submitted mitigation targets [19], as have 45 developing country Parties [20]. Some developing country Parties have noted the need for international support in their plans.As a part of the Cancún agreements, developed and developing countries have submitted mitigation plans to the UNFCCC [21, 22]. These plans are compiled with those made as part of the Bali Action Plan.UNFCCC's meetings and conferences are organized regularly, recently, Bonn Climate Change Conference was held on April 2018.

Conclusion

Climate change is the defining challenge of our time, yet it is still accelerating faster than our efforts to address it. Atmospheric level of carbon dioxide is higher than it has been for 800,000 years, and it is increasing. So, too, are the catastrophic effects of our warming planet – extreme storms, droughts, fires, floods, melting ice and rising sea levels.

In 2015, the world's nations recognized the urgency and magnitude of the challenge when they adopted the historic Paris Agreement on climate change with a goal of limiting global average temperature rise to well below 2°C while aiming for a safe 1.5°C target. The unity forged in Paris was laudable – and overdue. But, for all its significance, Paris was a beginning, not an end. The world is currently not on track to achieve the Paris targets. We need urgent climate action and greatly increased ambition – in emissions reductions and in promoting adaptation to current and future impacts of climate change.

Success demands broad-based concerted action from all levels of society, public and private, action coalitions across all sectors and the engagement of all key actors. There is no time, nor reason, to delay. The dogma that pollution and high emissions are the unavoidable cost of progress is dead. Investing in climate action makes sense for the global environment, improved public health, new markets, new jobs and new opportunities for sustainable prosperity. Failing to act will simply consign all of humanity to ever-worsening climate calamity.

There is much to do in 2018. We need to support Parties to increase pre-2020 action. Those Parties that have not yet done so should ratify the Doha Amendment to the Kyoto Protocol. Parties should use the Talanoa Dialogue as an opportunity to engage with one another and increase ambition under the Paris Agreement. In 2018, it is critical that the outcomes of the Paris Agreement work programme are adopted at COP 24 in Katowice to ensure we are ready for the implementation of the Agreement [23].

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IRAN'S COMMITMENTS TOWARD MEETING THE GOALS OF PARIS AGREEMENT HARNESSING THE GLOBAL TEMPERATURE RISE

Yousef Sobouti
Institute for Advanced Studies in Basic Sciences, Iran Academy of Sciences, Zanjan, Iran
Email: sobouti@iasbs.ac.ir

Since its inception in Rio, 1992, United Nations Framework Convention for Climate Change (UNFCCC) has held 23 Conference of Parties (COP). COP21 of Paris, December 2015, by consensus, is a breakthrough in more than 25 years of debates and disputes over climate change and global warming issues. COP21 invites the world players to reduce the Global Greenhouse Gas (GHG) emissions, to limit Planet's temperature rise to below 2 degrees Celsius, if not below 1.5, by the end of the 21st century. To meet the challenge, the main recommendations of the agreement are as follows: COP21 invites its member to propose an intended Nationally Determined Contribution (NDC), towards meeting its goals, proportionate to their administrative, economic, and technological capabilities. NDCs are required to be Measurable, Reportable, and Verifiable (MRV). NDCs should be revised every 5 years on the basis of knowledge and experience gained in the process. COP21 urges the developed countries to assist the developing ones, technology-, finance-, and knowhow- wise to develop and execute their NDCs. Recommendations of COP12 are nonbinding. Islamic Republic of Iran is a member of UNFCCC since 1996. President H. Rouhani attended the Paris Conference and pledged to reduce Iran's GHG emissions: a) Voluntarily by 4% in the period 2020-30; and b) Conditionally by an additional 8% by 2050. The reference year for GHG reductions is 2010 on BAU basis. Conditions for the 8% reduction are, the availability of financial and technological means, and lifting of the sanctions imposed upon the country. Again, the pledges are non-binding, as for all UNFCCC parties. A Working Group on Climate Change (WGCC), stationed in the Department of Environment of Iran (DOE), is the liaison with UNFCCC. WGCC is given the task of drawing up Iran's NDC. A first draft of this document is now available to public.

Keywords: *climate change, Paris Agreement, GHG emissions, adaptation, Iran.*

Introduction

Since its inception in Rio, 1992, United Nations Framework Convention for Climate Change (UNFCCC) has held 23 Conference of Parties (COP). The Latest, COP23, was presided by the Fiji government with the support of Germany in Bonn, November 2017. COP21 of Paris, December 2015, by consensus, is a breakthrough in more than 25 years of debates and disputes over climate change and global warming issues. COP21 invites the world players to reduce the Global Greenhouse Gas (GHG) emissions, to limit Planet's temperature rise to below 2 degrees Celsius, if not below 1.5, by the end of the 21st century. To meet the challenge, the main recommendations of the agreement are as follows:

- COP21 invites its member countries, to propose an intended Nationally Determined Contribution (NDC), towards meeting the goal of COP21, proportionate to their administrative, economic, and technological capabilities.
- To ensure realization of the NDCs, COP21 requires its members to submit, bi-annually, a Measurable, Reportable, and Verifiable (MRV) document explaining the State of their NDCs.
- COP21 recommends revision of NDCs every 5 years on the basis of knowledge and experience gained in the process.
- COP21 urges the developed countries to assist the developing ones, technology-, finance-, and knowhow- wise to devise and execute their NDCs.

Recommendations of COP21 are nonbinding. They are meant to draw attention of the governments and people everywhere in the world, to the fact that a warming planet endangers the existence and wellbeing of all societies and bio systems.

Islamic Republic of Iran as a member of UNFCCC

Islamic Republic of Iran is a member of UNFCCC since 1996. Its representative in UNFCCC is the Department of Environment (DOE) of Iran. A Working Group on Climate Change (WGCC), stationed in DOE is its liaison. The President of the Islamic Republic of Iran, His Excellency Hassan Rouhani attended the Paris Conference and pledged to reduce Iran's GHG emissions:

a. Voluntarily by 4% in the period 2020–2030; and
b. Conditionally by an additional 8% (totaling 12%) by 2050.

The reference year for reduction of the GHG emissions is the year 2010 on business as usual basis. Conditions for the 8% reduction are, the availability of financial and technological means, and lifting of the sanctions imposed upon the country. Again, the pledges are non-binding, as for all UNFCCC parties.

WGCC is given the task of drawing up Iran's NDC. A first draft of this document is now available to public. The main items in Iran's NDC are the following:

1. The energy sector of Iran is responsible for more than 80% of country's GHG emissions. Provisions to reduce them are:
- to replace old single cycle gas turbines by combined cycle plants;
- to develop new combined cooling-heating and power plants;
- to replace the coal and oil burning plants by gas burning ones;
- to initiate structural changes in technical configuration of oil refineries and improve energy efficiency in oil & gas refineries;
- to prevent leaks in the country-wide oil and gas pipe lines and in electricity distribution grids.

2. The energy intensity of the country's industrial production and building sector is unacceptably high, twice that in the region, four times that in Europe, and almost nine time that in Japan. Recommendations are:
- to review and upgrade routine maintenance check lists in all steps of production;
- to replace old technologies by modern ones;
- to create agile managements from top to bottom;
- to replace the coal and oil burning plants by gas burning ones.

3. Fugitive gases from oil and natural gas fields, refineries, and petrochemical plants in 2010 constituted 18% of GHG emissions of the Country (table). It is somewhat lower now. Researchers of Sharif Energy Research Institute (SERI) estimate that collection and reuse of 75% of the fugitive gases is possible and can reduce Iran's CO_2 emissions by 5%, one percent more than the voluntary pledge of the country. If reduction in methane emission is included, further reduction of GHG emission by 11%, can be accomplished. These two items add up to 16%, significantly more than the total 12% voluntary and conditional pledges of the country. The main obstacle on the way of implementation of such an ambitious, but a doable policy is the international political tension and exertion of sanctions on the country.
4. Presently, the hydropower capacity of Iran is 12-15%. In the face of global warming, and reduced precipitation in the mid-latitude dry and warm Iran, however, this potential is expected to decline rapidly.
5. Contribution of Renewable Energies, solar heating, solar photovoltaics, wind and biomass, to the energy mix of the country is, presently, insignificant. But it can be increased significantly, as part of the country's NDC. Main obstacles in the development of renewables are the heavily subsidized prices of oil and natural gas in the country, scarcity of capital and inaccessibility of efficient technologies. These factors leave no incentive for prospective private investors to come forward.

Vulnerabilities

- Mid-latitude Iran is dry and warm, is located in the main global dust belt bellowing easterly and bringing in the dust storms of African Sahara, the Arabian peninsula and the Mesopotamian plateau.
- Iran's annual precipitation is one third of the global average. Evaporation from its wetlands is three times that of the global average.
- Considering its expanse of 1.6 million square kilometers, Iran's share from the world's forests is one third, and from its deserts is three times the world average.
- In the past ten years programmable water of the country has dropped from 130 to 90 billion m^3. Projections indicate that there will be further reduction to one half by 2030.
- Model simulations show that Iran's temperature rise by 2030 will reach 1.5 degrees Celsius. This means an additional annual loss of 10 billion m^3 of water from the wetlands and agricultural fields of the country.

Potentials for Adaptation and Mitigation

A good fraction of the Iranian population is young and educated while most of Iran's problems, in coping with global warming, demand low tech solutions. Low tech is available country-wide. To reduce losses in the delivery of water, gas, and electricity from production points to consumers' doors is a household knowhow, available everywhere.

There are, however, serious obstacles. Government controlled economy, bureaucratic administration, and lack of discipline in industrial productions to manufacture standard products are among the most distractive factors on the way of steady and sustainable development of the society.

Nonetheless, researchers in SERI and else-

Table

GHGs Emission Inventory of Iran, 2010 (Kton)

Sources	CO_2	CH_4	N_2O	Total
1. Energy	584,451	5,437	4.0	699,868
Fuel Combustion	543,569	71	4	546,300
Fugitive Emissions	40,882	5,366	0	153,568
2. Industry	67,840.8	29.8	4.5	69,846
3. Agriculture	598.8	966.1	75.7	44,367
4. Forestry	9,181	0.3	0.0	9,187
5.Waste	29.0	1,308.2	1.3	27,905
Total GHG's Emissions	662,101	7,741	85	851,173
GWP	1	21	310	
Total CO_2 Equivalent	662,101	162,570	26,502	851,173

Source: Iran's third National Communication

where in the country, maintain that with well thought planning and management, Iran can reduce its GHG emissions by about 40% by 2050. Private investors, domestic and/or foreign, should be encouraged to come forward. The initial investment may be high, but the return of the capital is quick and profits are rewarding.

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BUILDING RESILIENCE AND POVERTY ALLEVIATION THROUGH TILAPIA-BASED SKILLS AND LIVELIHOOD DEVELOPMENT IN NORTHERN MINDANAO

Proserpina G. Roxas*, Elgin M. Arriesgado, Lee-Marc C. Alia, Floremie Bagayna, Merriam Danielle P. Gomez, Daniel M. Gonzales, Mark Anthony J. Navarro, Victor M. Navarro, Eugene P. Moleño, Aida D. Perpetua, Roseller G. Sabilla
Mindanao State University at Naawan, Misamis Oriental, Philippines
Email: proseroxas@yahoo.com (*corresponding author)

The project aimed to teach beneficiaries skills and assist them in establishing a tilapia-based livelihood, with the objective of building resilience and alleviate indigence amidst environmental challenges. A survey of organizations and site evaluation were conducted to determine qualified beneficiaries and suitability of area. Thirteen people's organizations, one Local Government Unit and a school were qualified as partner-beneficiaries. They were trained the technologies on tilapia hatchery operations, tilanggit production and tilapia grow-out and were assisted in starting their own livelihoods, applying the acquired skills. Start-up materials were provided: fingerlings, cage materials, feeds and equipment. They were also given trainings on value-adding, feed formulation, entrepreneurship, bookkeeping, gender and development, and climate change. Government agencies were engaged for sustainability of the initiative. At the end of the project, seven organizations were already operating their hatcheries, producing fingerlings for their use and for market. The tilanggit processed by women were highly demanded in markets and festivals. Their grown-out tilapia is sold in retail and in bulk. As a strategy, the beneficiaries planted indigenous trees in river banks in exchange for free fingerlings. It was shown that bringing science to poor communities helps mitigate impacts of climate change.

***Keywords**: resilience, tilapia, tilanggit, livelihood, climate change.*

Tilapia as a source of income

Tilapia (*Oreochromis* spp.) has been referred to as the "aquatic chicken" as it can grow fast, breed easily and is very hardy. Its culture and propagation is simple and requires low feed inputs and water quality management. Tilapia grow-out has been a good source of income in many parts of the world. The drawback however is that the fish is marketable only at least 4 months after stocking hence a grower is left penniless for the time that the fish is being cultured. Three tilapia-based technologies are being promoted by the Mindanao State University at Naawan, as sources of income, namely: hatchery operations for fingerling production, tilanggit production and grow-out culture. These technologies are interrelated. Hatchery operation is desirable because aside from the income from selling fingerlings, it ensures a stable supply of the seeds for grow-out culture. Tilanggit production allows intense stocking density for a given culture space because 2-month old fish can be thinned out for tilanggit processing leaving only the number equivalent to the carrying capacity of the facility. A reality that emerged from several studies is the absence of livelihood options for fisherfolks and some sectors like the women and the youth. The technology on tilanggit production can be taught to these sectors so they can have a source of income without necessarily abandoning the household responsibilities that are associated with wives and women. The processing can be done even in their own kitchen hence is considered a good source of income for non-working members of the household. Grow-out is the most common livelihood activity but many are prevented from engaging because they are constrained by limited supply of fingerlings. Records have also shown that fishing communities are among the most vulnerable groups to climate change impacts. Teaching them skills and providing them assistance in starting a livelihood applying the skills they have acquired could be a key to preparedness. Anchored on these premises, the project hoped to alleviate poverty among fisherfolks and make them more resilient to the impacts of environmental challenges.

With funding from the Commission on Higher Education, we shared the technologies to fishing communities with two goals: 1) To contribute to the income, food security and nutrition of vulnerable households through tilapia-based skills and livelihood development, and 2) to contribute to resilience building of the fishery ecosystems and the communities dependent on them amidst potential impacts of climate change.

Initial activities included entry protocols, identification of vulnerable communities with the help of the local government units, and assessment of sites for suitability to tilapia-based activities. Carefully selected representatives from each partner organization underwent skills training on the three technologies. For sustainability and holistic development, skills training and livelihood development were paralleled by other relevant trainings, namely: entrepreneurship and bookkeeping, marketing, gender and development, climate change, and feed formulation. A training on entrepreneurship and marketing was conducted to prepare them to enter the tilapia industry. A seminar-workshop entitled bookkeeping for non-bookkeepers and accounting for non-accountants was necessary because many organizations fall apart due to unsound financial management. The organizations were proactively capacitated to handle finances. An activity on gender and development, with emphasis on the roles, functions and opportunities in gender within the fisheries sector, could bring about awareness that both husbands and wives can equally contribute to achieving development goals. Because building resilience amidst climate change was a goal, people's understanding of the climate change issue was addressed through training-workshop that included resource mapping with emphasis towards climate resiliency and sustained resources management. Since the project can provide only start-up feeds for their livelihood, the partner communities were also taught to formulate feeds using indigenous materials. In other words, the process of transferring the tilapia-based technologies included lectures, training-workshops, hands-on activities, and on-site livelihood establishment.

A total of 12 people's organizations, a local government unit and a Fisheries school in Northern Mindanao, Philippines were chosen as project partners. The socio-economic survey and livelihood profiling revealed that households in these areas were living on a hand-to-mouth existence with no clear livelihood options.

Training and seminars: establishing a tilapia-based livelihood

21 individuals from the various partner organizations took part in the training on tilapia hatchery management. The activities included lectures coupled with actual exercise on broodstock selection, maintenance of good-quality broodstock, sex identification, classification of Tilapia species used in aquaculture, breeding or spawning enclosures, hatchery methods, and ways to increase production yield and, sex reversal and its advantages. Based on the participants' performance and the readiness of their facilities back home, some broodstocks were a take-home for some trainees so that they could already start their hatchery operation. The ocular visits to the partners' areas revealed that a hatchery complex owned by a local government unit had remained idle for years. Technical assistance was provided to rehabilitate the facility and broodstocks were given for the facility to immediately operate. Within the duration of the project, tilapia hatchery was already operational in five project sites, with highest fingerling production in this LGU-owned hatchery complex. The local government had already dispersed significant number of tilapia fry/fingerlings. The other groups that succeeded in establishing hatcheries had intensified their grow-out activities because their fingerling supply was already sufficient.

Another set of representatives from partner organizations, mostly women and youth, joined the training on tilanggit processing and production. *Tilanggit* is a dried tilapia product well-known for its taste and crunchiness, meatier, tastier and crunchier than any dried fish product. Tilapia is prolific, matures sexually at 90 days, escalating food competition when cultured. But a shorter culture period could mitigate competition. In tilapia farming for tilanggit production, fingerlings are stocked at its maximum stocking density in shorter period, to body weight of 20-30 grams. These approximately 2-month old tilapia are then processed for tilanggit.

The technology on tilanggit production was successfully adopted by three organizations only. The products of these organizations were already sold locally, displayed in trade fairs and in some supermarkets. One adopter, a federation of fisherfolks, had already transferred the same technology to members of its federation. For the other partner organizations, the low adoption of the technology was attributed to organizational dynamics like movement of trained members to another place, or withdrawal of membership from the organization, or simply was more focused on the grow-out culture. The project committed to conduct an on-site training under its regular extension activities, as per request from the partner organization. The success among the few adopters of the tilanggit technology can be attributed to the groups' implementation strategy. To persuade members to participate in the processing, the organization adopted an incentive scheme. For every volume of fish processed to tilanggit, a member got a corresponding volume of fresh fish to be brought home for the family. The impact was good because for members, there was an immediate gain for the effort of participating in the processing, in addition to the share from the organizational sales. Socially, the members got pre-occupied

with the work instead of just sitting down and playing cards and the like. Monetarily, *tilanggit* production showed a viable earning of 31.47% in just 2 months of culture. The ROI could potentially increase once volume is increased. According to the group, it was better to engage in *Tilanggit* production rather than put the money in the bank which may earn only 2-4% for annual time deposit.

A special partner of MSUNaawan in this project is the Iligan City National School of Fisheries (ICNSF). Per request by the school head, some of its faculty members joined the training on tilanggit production. The faculty in turn transferred and shared the technology to their students. As an offshoot, a training for the parents of the students was initiated through the Parents-Teachers' Association.

Knowledge on packaging and value adding for *tilanggit* is necessary to ensure competitiveness in the market. Training on this marketing component, participated by 24 representatives from the partner organizations, was therefore organized and conducted in collaboration with the Department of Trade and Industry (DTI) Caraga Region.

The team also conducted training on feed formulation, putting emphasis on the use of available local materials. In all the trainings, the participants joyfully expressed appreciation for the skill they have acquired, saying that the same skill can be used in other livelihood activities like feeds for piggeries, pancit- and noodle-making and the like. All organizations were equipped by the project of the basic gadgets for feed formulation, including a corn mill and a pelletizer. These would already enable them to immediately start formulating feeds, taking advantage of abundant raw materials like corn bran.

Tilapia-based technologies: operating practices

Tilapia grow-out has long-been seen as a promising industry. All partner organizations adopted the grow-out technology upon return to their place. The size and the design of their cages varied, depending on water supply, relative location, and some other factors unique to the locality. Some cages were established along the river where current is continuous and unidirectional while the fish grown in relatively stagnating lakes maybe exposed to lower-oxygen environment. The results of the grow-out revealed some new information for aquaculture as well as the state of the environment. The groups that established their cages in an environment where shrimps were abundant invested only a little for the feeds yet had a good harvest. The fish turned out to have a good high-protein supply because they were feeding on the natural food, mainly the shrimps, available in the environment.

In another group that established their cages along the Agusan River, the return of investment was also very high. This was attributed to the good water exchange in flowing water, providing good oxygen supply to the fish. However, the presence of janitor fish in the river was further confirmed in this project. The intrusion of this pest was already reported in previous studies. When the nets were lifted out of the water during harvest, the nets already had holes which could mean that some fish had escaped hence affecting their total harvest. But the average body weight of the fish cultured in the river was higher than those grown in standing waters. Other groups also reported that they were using some natural food supplements like squash, camote tops, *kangkong* and other edible plant materials available in their area. Given these variations in their feeding management, it was very difficult to compare growth performance of the fish among the project sites. Suffice to say though that the grow-out technology was successfully adopted, with the beneficiaries introducing some innovations in management to achieve good harvest. These innovations have become the subjects for research with the goal of determining the most effective culture system in the natural environments experienced by the different groups.

Workshop-seminar on climate change

Another project was the workshop-seminar on climate change focused on mapping resources and vulnerable areas and brainstorming on activities aimed to mitigate measures that would lessen the negative impact of deleterious weather disturbances. To ensure that such measures would be adopted by group members, the chosen participants were the leaders of the organizations. The project team's staff provided lecture inputs on climate change and also facilitated the workshop on mitigating measures. We also recommended protected sites for cage establishment but raised the issue on how to continually protect their environment. The group agreed to plant indigenous trees along the banks. In exchange, the project gave them free fingerlings for every tree planted. The project also extended technical assistance to the community groups on how to construct flood-resistant cages, along with the provision of essential cage construction materials.

To further sustain the initiative, an agreement with the Bureau of Fisheries and Aquatic Resources was crafted, for them to continue assisting the organizations. Overall, the goals were achieved and researchable areas were identified, specifically in developing aquaculture structures that are adoptive to environmental changes.

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SUSTAINABLE INTENSIFICATION OF AGRICULTURAL SYSTEMS IN IRAN FOR ADAPTATION TO CLIMATE CHANGE: OPPORTUNITIES AND CHALLENGES

Abdolmajid Mahdavi Damghani
Department of Agricultural Sciences, I.R. Iran Academy of Science
Department of Agroecology, Environmental Sciences Research Institute,
Shahid Beheshti University, Tehran, I.R. Iran
Email: mmd323@yahoo.com

Attaining sustainable food security in Iran, as a country located on an arid and semi-arid region requires overcoming many challenges including limited basic resources (water and arable land), improving food safety and health and increasing productivity of agroecosystems as well as reconstructing market and affordability to food. Climate change has further threatened country's capabilities for sustainability of agricultural systems. Reconsideration for intensive farming due to diminished quality and quantity of water, soil, and biodiversity resources which are caused by long time conventional practices is a necessity for providing sustainability of agroecosystems in Iran. Food security, however, should not be declined in the process; so, we need a new paradigm of "sustainable intensification" which integrates food security and meanwhile ecological sustainability of these systems. Sustainable intensification is a prerequisite of adaptation for climate change in Iran, as adaptation needs to reduce water consumption and increase water use efficiency (WUE), optimize soil tillage and management and maximize productivity of whole production chain. This would be done in triple steps including reducing input consumption, replacing conventional inputs and practices by integrated and sustainable ones and finally recreating and redesign climate- resilient agroecosystems. Opportunities and challenges of the duty are reviewed in the current work.

Keywords: *food security, resilience, sustainability, Iran.*

Introduction

Iran is the second largest country in the Middle East, with an area of 1.65 million km^2. It has been a center for the evolution of agriculture, people engaged in agriculture first settled here some 10000 years ago [5]. Since Iran spans a wide range of latitudes and longitudes, it also has a diverse range of physiography, climate, vegetation and biological productivity. Rangelands constitute 35%, deserts and degraded lands 21%, forests 7.4%, agricultural land 14.4% and urban areas, lakes and other lands 2.2% of the total area of the country [8]. Over 18 million ha of land are used for agriculture, producing 100 MT of food, from field crops to horticultural products, for a population of 80 million. Currently, 3.4 million farmers in Iran cultivate 18.5 million ha [7]. Different types of farming systems and land tenure can be found throughout the country, from commercial to subsistence farms. Statistics published by FAO [4] showed that agriculture in Iran is consuming 17.6 kg N ha^{-1}, 7.5 kg P ha^{-1} and 1.3 kg K ha^{-1} annually. Data on country food security indicate that 5.5% of population is experiencing different kinds of food insecurity and hunger. Table 1 draws a comprehensive picture of agriculture in Iran.

Agriculture has a long history in Iran. It has been argued that dryland farming first evolved in the western part of the country about 10000 years ago, simultaneously with the domestication of goats and sheep [5]. Farmers have managed their traditional agroecosystems for centuries by focusing on sustaining long-term yields rather than maximizing yields in the short term. Land management was based on practices and knowledge associated with self-reliance and family units within communities. This system of land use evolved on the basis of the following structural and functional principles [8]:

- Consideration of high species numbers and structural diversity in time and space (vertical and horizontal organization of crops and animals);
- Exploitation of a wide range of microenvironments (soils, water, temperature, altitude and fertility);
- Recycling practices for materials and wastes;
- Reliance on biological interdependencies;
- Reliance on local resources plus human and animal energy (low input technology);
- Reliance on local crop varieties and incorporation of wild plants and animals;
- Implementation of collective production activities based on self-sustained and self- sufficient communities.

Table 1

Iran metadata on agriculture [4]

	1990	2000	2014
The Setting			
Population, total (mln)	54.6	65.9	78.5
Population, rural (mln)	24.6	23.7	23.9
Govt expenditure on ag (% total outlays)		3	1.4
Area harvested (mln ha)	14	13	22
Cropping intensity ratio	0.2	0.2	
Water resources (1000 m^3/person/year)	2	2	2
Area equipped for irrigation (1000 ha)			9553
Employment in agriculture (%)		23	21.2
Employment in agriculture, female (%)		16.7	30.6
Fertilizer, nitrogen (kg of nutrients per ha)		52.5	17.6
Fertilizer, phosphate (kg of nutrients per ha)		21.6	7.5
Fertilizer, potash (kg of nutrients per ha)		6.3	1.3
Energy consump, power irrigation (mln kWh)	2	219	1688
Agr value added per worker (constant US$)	2122	2558	3313
Food security dimensions			
Dietary energy supply (kcal/pc/day)	2950	3045	3287
Average dietary energy supply adequacy (%)	135	130	138
GDP per capita (US$, PPP)	8679	10694	15090
Improved water sources (% pop)	92.2	94.1	95.9
Food supply			
Food production value, (mln $)	12210	17582	25588
Agriculture, value added (% GDP)	19	14	10
Food exports (mln $)	345	904	3970
Food imports (mln $)	2211	2484	9668
Net trade (mln $)			
Cereals	-981	-1465	-4387
Fruits and vegetables	262	452	1305
Meat	-290	-33	-506
Dairy products	-161	-49	188
Fish	37	14	178
Environment			
Forest area (%)	7	7	7
Terrestrial protect areas (% total land area)	6	6	7
Biofuel production (1000 kt of oil eq.)	4	13	1
Net GHG emission from AFOLU (CO2 eq. Mt)	37	43	38

Climate Change in Iran and Its Effects on Agricultural Production

Iran, like other parts of the world has been affected by climate change. Koocheki et al. [11] using 40 year meteorological data of 34 cities studied the effects of climate change on Iran agriculture. According to predictions of two general circulation models (GCMs), results showed that annual mean temperature on 2050 will increase 3.5–4.5°C. Results also revealed that annual precipitation will decrease on 2050 comparing current situation by 7–14%. Results clearly show that growing season will increase and freezing-free days will decrease in all studied areas. It means that in all part of country, even in cold areas, growing season will increase and improve the condition for crop production. However, it should be mentioned that longer growing season without appropriate soil water content would not be any advantage for crop growth and yield; therefore, actual growing season will be decreased in most parts of the country which imposes another limitation for dryland crop production. As shown in Figure 1, duration of dry season will be 21–30 days longer in different parts of the country.

Alizadeh and Kamali [1] showed that 2, 4 and 6°C temperature increase in Mashhad Plain will increase net irrigation demand of current cropping pattern by 6, 11 and 17%, respectively. Results of Ebrahimi [2] in Khorrasan Razavi Province showed that water demand of the region at 2050 will increase 22% comparing current demand.

Koocheki and Nassiri Mahallati [10] applying General Fluid Dynamic Lab (GFDL) showed that on 2050 comparing current condition, the yield of 4 staple crops including wheat, maize, chick pea and sugar beet will be decreased; the highest and lowest decreased was reported for sugar beet and chick pea, respectively (Figure 2). Koocheki and Kamali [9] studied the effects of climate change on rainfed wheat production in Iran and reported that at 2025 and 2050 yields will be lower by 16–24% and 22–32%, respectively.

Adaptation *vs.* Maladaptation to Climate Change

There are two main policy responses to climate change: mitigation and adaptation. Mitigation addresses the root causes, by reducing greenhouse gas emissions, while adaptation seeks to lower the risks posed by the consequences of climatic changes. Both approaches will be necessary, because even if emissions are dramatically decreased in the next decade, adaptation will still be needed to deal with the global changes that have already been set in motion.

Climate change adaptation helps individuals, communities, organizations and natural systems to deal with those consequences of climate change that cannot be avoided. It involves taking practical actions to manage risks from climate impacts, protect communities and strengthen the resilience of the economy. Adaptation can involve gradual transformation with many small steps over time, or major transformation with rapid change.

The adaptation strategies are intended to inform and assist communities in identifying potential alternatives. They are illustrative and are presented to help communities consider possible ways to address anticipated current and future threats resulting from the changing climate. In particular, it is important to note [3]:

- The strategies presented are not a comprehensive or exhaustive list of resiliency or adaptation ac-

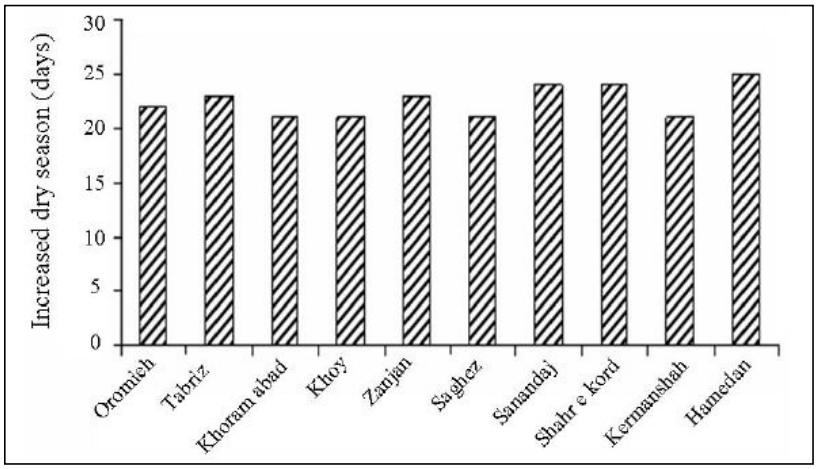

Figure 1. Predicted increase in the length of dry season for year 2050 compare to current conditions in the main rainfed production regions of the country, changes were predicted using GFDL model [11]

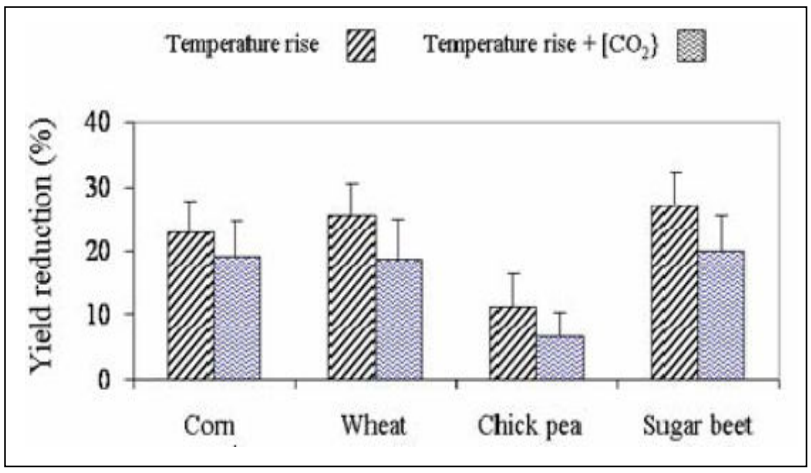

Figure 2. Predicted yield reduction in the studied crops for the year 2050 compared to current yields, yield are predicted using SUCROS model under temperature rise and temperature rise + increased CO_2 concentration. Vertical bars show SE of regions [10]

tions that may be relevant.

- None of the provided alternatives are likely to be appropriate in all circumstances; the appropriateness of each alternative should be considered in the local context for which it is being considered.
- The potential strategies are largely drawn from EPA and other federal resources. Before adopting any particular strategy, it should be considered in the context provided by the primary source document from which it originated. Source document(s) are indicated.
- The presented strategies should not be relied on exclusively in conducting risk assessments, developing response plans, or making adaptation decisions.

As mentioned earlier, Agriculture is a major part of the climate problem; it currently generates 11 to 29% of total greenhouse gases emissions. Therefore, Climate-Smart Agriculture (CSA) aims to make the agriculture sector better-suited to handle the challenges of a changing climate by sustainably increasing agricultural productivity; helping food systems adapt and building their resilience; and reducing GHG emissions. This is what we call "adaptation to climate change". However, there is always a devastating danger of accepting and application of "maladaptation" mechanisms which are defined as false and pseudo-solutions for problems. Indeed, maladaptation refers to adaptations which are neither appropriate nor sustainable in a specific condition.

According to its definition, sustainable agriculture is a "site-specific" paradigm which implies there is not a general rule for everywhere. In other words, adaptation in an area may be maladaptation in another area according to sustainability criteria. There are many cases of maladaptation in agriculture of Iran during last decades. In the case of water and irrigation, digging deep well which has resulted in severe water shortage is a maladaptation to drought and water stress. Conventional tillage in vulnerable and low-organic content soils of country is another maladaptation for soil management and finally introduction of hybrid seeds and high-demand varieties is another maladaptation to country need for more food production. So, good governance for management of climate change and minimizing its effects on agriculture, environment and natural resources requires "sustainable adaptation" that is formulated in the concept of sustainable intensification.

Sustainable Intensification: Sustainable Adaptation to Climate Change in Agriculture

Sustainable intensification has been defined as a form of production wherein "yields are increased without adverse environmental impact and without the cultivation of more land" [6]. It provides a framework for exploring what mix of approaches might work best based on the existing biophysical, social, cultural and economic context and a growing body of work is starting to emerge that explores what implementation might look like in practice.

Food outputs by sustainable intensification have been multiplicative– by which yields per hectare have increased by combining the use of new and improved varieties and new agronomic– agroecological management …and additive – by which diversification has resulted in the emergence of a range of new crops, livestock or fish **[13]**. It should be mentioned that none of the components of this paradigm are new. They comprise techniques of ecological and genetic intensification, within enabling environments created

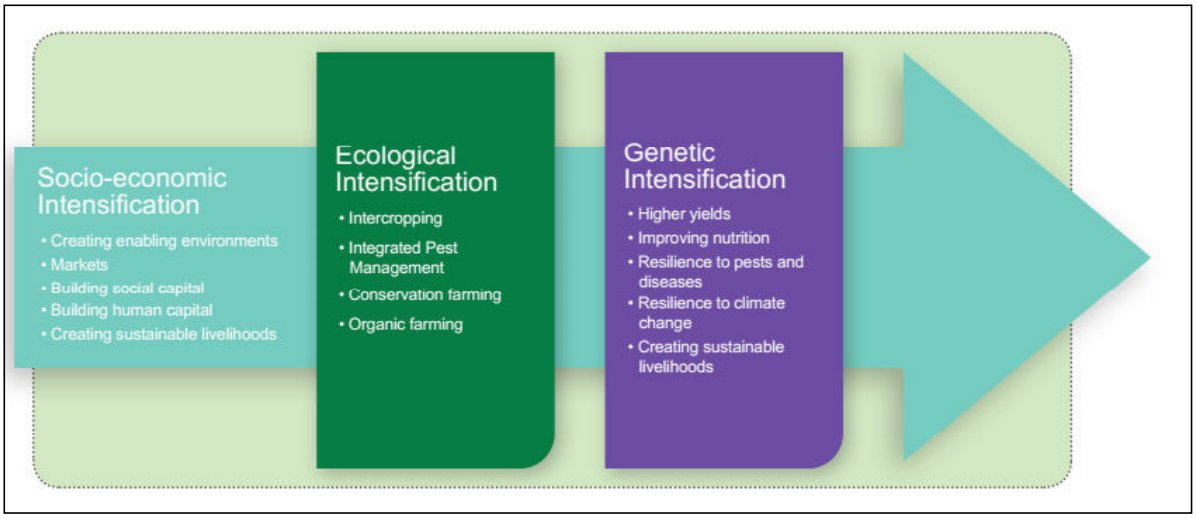

Figure 4. The practical approaches to Sustainable Intensification [14]

by processes of socio-economic intensification. What is new in this approach is the way in which they are combined as a framework to find appropriate solutions to world's food and nutrition crisis. The theoretical model for sustainable intensification is shown in Figure 3. Defined in this way, sustainable intensification is an ambitious objective but is achievable if we focus on being [14]:

- ***Prudent***, in the use of inputs, particularly those which are scarce, are expensive and/or encourage natural resource degradation and environmental problems;
- ***Efficient***, in seeking returns and in reducing waste and unnecessary use of scarce inorganic and natural inputs;
- ***Resilient***, to future shocks and stresses that may threaten natural and farming systems;
- ***Equitable***, in that the inputs and outputs of intensification are accessible and affordable amongst beneficiaries at the household, village, regional or national level to ensure the potential to sustainably intensify is an opportunity for all.

Sustainable intensification looks for optimizing returns on inputs while preserving resources. It is increasingly relying on new technologies like satellite imagery, information technology and geospatial tools. For example, they may analyze and plot in detail the nutrient levels in different parts of their fields and then use tractors equipped with satellite positioning systems to apply different fertilizer mixes in accordance with soil needs in specific locations.

In this paradigm, soil and nutrient management should be based on efficient application and uptake of nutrients from chemical, biologic as well as organic resources. Between 1960 and 2000 the efficiency of N use for global cereal production decreased from 80%

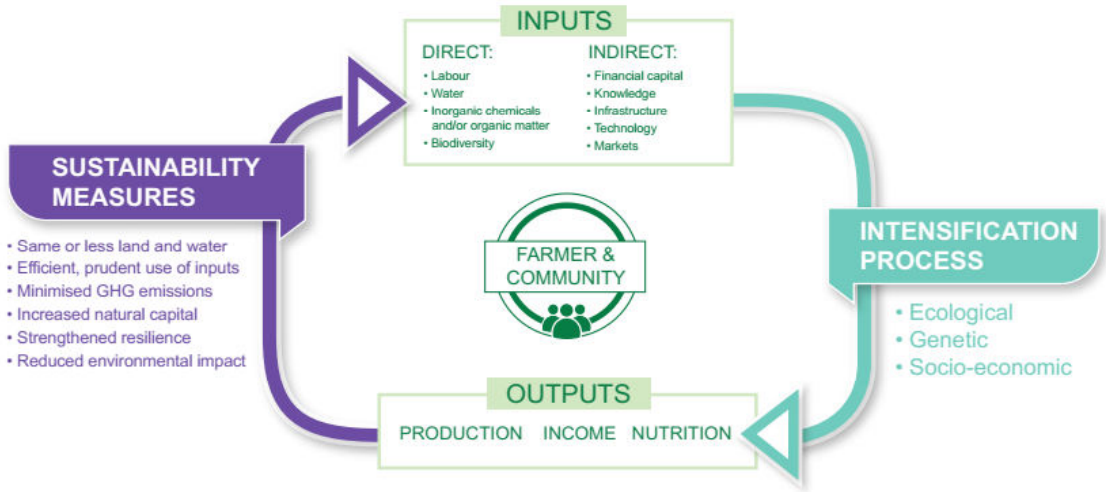

Figure 3. The theoretical model for sustainable intensification [14]

to 30%. Farmers in countries like Iran need to strike the right balance between managing soil organic matter, fertility and moisture content and the use of fertilizers. One highly efficient and intrinsically sustainable approach is the technique of micro dosing developed to both minimize the application of and over reliance on inorganic fertilizer and to improve nutrient use efficiency and protection against drought. The same principle can be applied to use of herbicides that, far too often, are sprayed relatively indiscriminately, killing not only weeds but other wild plants and sometimes damaging the crops themselves. Applying precision farming techniques simultaneously addresses the challenge of combating serious weed problems in Africa – such as *Striga* (or witchweed), which sucks nutrients from the roots of maize, sorghum, millet, cowpea and other crops – while minimizing any unintended or undesirable environmental impacts [14].

As with nutrients, water has to be available for crop uptake in the right amounts and at the right time, as water stress during growth results in major yield reductions for most crops. In these and other examples, the interconnectedness of water, soil and nutrient conservation is critical. The most successful systems are those that provide water, nutrients and a supportive soil structure in a synergistic fashion. Figure 4 explains the practical approaches to sustainable intensification for countries like Iran.

Conclusion

Applying sustainable intensification principles in agroecosystems for adaptation to climate change is a gradual and step by step process. Transition to sustainable intensification in Iran does not affect agricultural production and farmer income. Furthermore, it does not push farmers to quit inputs and practices of intensive agriculture. Finally, design and management of agroecosystems based on this paradigm need to careful consideration of site-specificity of any agroecosystem. Governmental support and access to education will guarantee the success of sustainable intensification globally [12].

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PERCEPTIONS AND RESPONSES TO CLIMATE CHANGE: UNDERSTANDING ADAPTATION STRATEGIES AND MULTI-LEVEL CAPACITIES IN NORTHERN BANGLADESH USING LIVELIHOOD RESOURCES

Iffat Ara
Tasmanian Institute of Agriculture, University of Tasmania, Australia
Department of Geography and Environment, Jahangirnagar University, Bangladesh
Email: iffatara.ju@gmail.com

Climate change has become a concern due to its adverse impacts on local livelihood and human security globally. This may affect livelihood options in a disaster-prone country, Bangladesh, particularly in the northern region, which experiences high temperature, low rainfall, and frequent disasters. This paper presents empirical evidences that indicate perceptions on climate change and local responses on this change to take different adaptation strategies using available livelihood resources. Primary data was collected in northern districts by applying Climate Vulnerability and Capacity Analysis method and Focus Group Discussion. The study demonstrated that local communities experienced climate variabilities and disaster incidents. Several adaptation strategies were employed at different levels of capacities based on livelihood resources. The study demonstrated government level capacity would mostly influence resources utilization. Policies and programs aimed at enhancing and strengthening the adaptation strategies need to deliberate livelihood resources and capacity levels significantly.

Keywords: *Bangladesh, climate change, disaster, livelihood resources, adaptation strategies, multi-level capacity***.**

Introduction

Climate change affected livelihood security in many countries globally. The intensity of changes and natural disaster occurrences varied due to the geographical location. The location of Bangladesh is particularly vulnerable of climate change and other disaster incidents [1, 29] and the country has frequently cited as a one of the most vulnerable country in the world [13]. However, country has developed several strategies to deal climate change impacts at the national level to improve livelihood [2, 3, 17], still several approaches need to rethink new strategies and to enhance capacities for better livelihood at the different parts of the country.

Several studies indicated that climate was changing and it became more unpredictable every year in Bangladesh [1, 12, 15]. The frequency and severity of many natural disasters were rapidly escalating because of climate change. Globally, it was evidenced that people used local knowledge and skills to understand climatic changes and to response it in emergencies [9, 10, 12]. Limited studies focused on climate change perception in Bangladesh. In addition, perception may differ in different location and people may use different approaches to response it. Therefore, understanding people's perception is critical to develop effective adaptation strategies, which will be feasible locally.

Globally many studies focused on adaptation strategies by considering local context. Very few studies identified adaption strategies due to climate change and natural disaster in Bangladesh [3, 4]. However, most of these studies focused on national level strategies, which may not suit at different regions of the country. A recent study particularly focused on flood resilience in wetland of the northeastern Bangladesh [14]. Government policies and action plans also focused on national level strategies by giving less emphasize on regional level [8, 25]. In many areas, local people use different strategies to combat climate change by using available resources. Therefore, location specific adaptation strategies need to consider in national polices and action plans.

Use of local resources seems to be a critical asset to tackle any emergencies globally [16, 18, 19, 26, 28]. The resilient Bangladeshi people have always coped with the effects of extreme weather events by using local resources. For instance, accessto agricultural land effectively contributed in post disaster rehabilitation process. Understanding key livelihood resources is important, that can be used to cope more efficiently in hazardous situation. However, inadequate study has been employed to understand the influence of livelihood resources on climate change resilience.

In addition to livelihood resources, multi-level capacities are also very important. Combating climate

change is often relying on multi-level capacities including individual, household, community, and government. Less attention has been paid to understand the strength of varied capacity levels in the country [20–22], which contributes in taking various adaptation strategies locally. In addition, these are useful to develop and implement action plans at regional level for better management of livelihood resources. The main objective of the present study is to understand local presentation and response to climate change in the northern Bangladesh by using livelihood resources at multi-level capacity. The specific objectives research are: (1) to understand local perception of climate change, (2) to recognize important livelihood resources for climate change adaptation, (3) to identify multi-level adaptation strategies and resource use for climate change resilience.

Data and methods

Study area

The present study focused on the northern part of Bangladesh, which experiences high temperature, low rainfall, and frequent disasters compared to the rest of the country. In total twelve sub-districts (upzila) in four districts of the northern Bangladesh were considered including Kurigram (Kurigram Sadar, Nageshwari, Chilmari), Nilphamari (Nilphamari Sadar, Dimla, Chilmari), Panchagarh (Panchagarh sadar, Tentulia, Jaldhaka), and Gaibandha (Gaibandha sadar, Saghatta, Sundarganj) (Figure 1). These were initially delimited based on available information and the degree of vulnerability of climate change and disaster incidents from historic records, literature review, and national newspaper reports from 1990 to 2010.

Data collection

The present study used Climate Vulnerability and Capacity Analysis (CVCA) method [5–6], particularly Participatory Research Assessments (PRA) exercises (100-semi-structured interview) and several Focus Group Discussion (FGD) using face-to-face interview method to assemble data by involving numerous target groups (GO, NGOs, communities, households and individual farmers) in the study area (Figure 2).

Data analysis

The collected information was processed qualitatively as well as quantitatively. Descriptive statistics included average to present graphs to understand the local climate change perception, disaster incidents, and available livelihood resources. Qualitative analysis was performed to identify adaptation strategies based on livelihood resources at various capacity levels using Nvivo. A corresponding score if 1, 2, 3, and 4 were assigned for individual, household, community, and government level capacity respectively to perform associated adaptation strategies. An adaptation strategy index [27] for use of individual livelihood resource was computed to identify the important resource at various capacity level as using to perform different adaptation strategies in the study area (1):

$$ASI = R_I \times 1 + R_H \times 2 + R_C \times 3 + R_G \times 4, \quad (1)$$

where ASI = adaptation strategy index, R_I = number of responses with individual resource use at individual level, R_h = number of responses with individual resource use at household level, R_c = number of responses with individual resource use at community level, R_G = number of responses with individual resource use at government level.

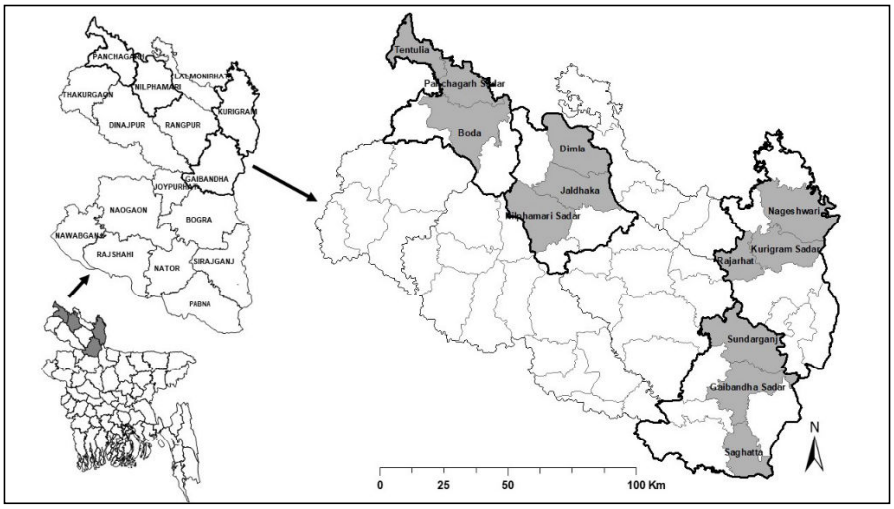

Figure 1. Study area including four districts and twelve sub-district in the northern Bangladesh (Source: prepared by author)

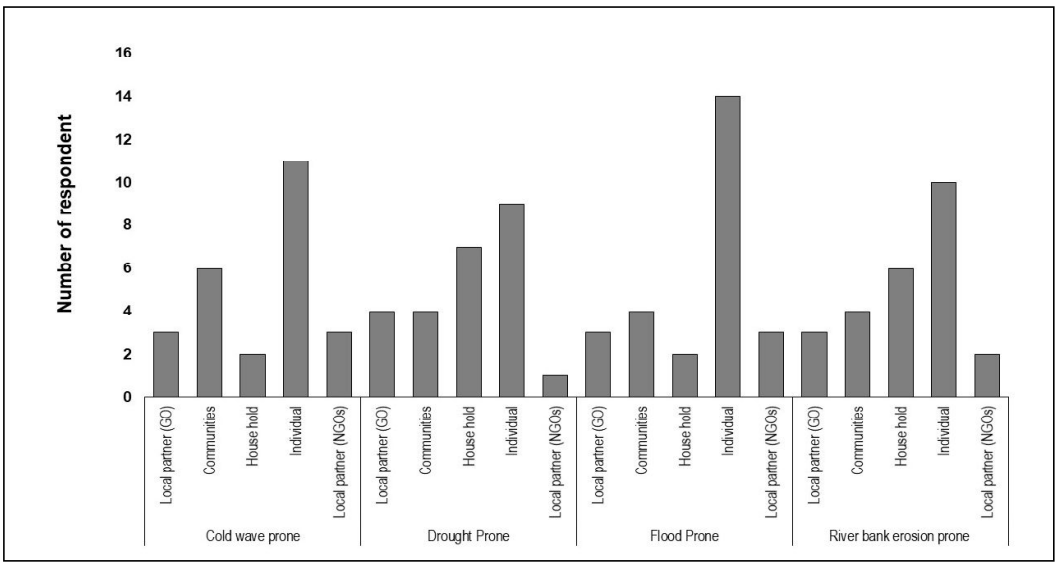

Figure 2. Number of respondents covered target groups in the study area (Source: Field survey)

A weighted average index [23] for different livelihood resource use was also calculated to find out the most relevant capacity level to use of these resources in the study area (Eq. 2):

$$CI = C_I \times 1 + C_H \times 2 + C_C \times 3 + C_G \times 4 / N, \quad (2)$$

where CI = capacity index, C_I = frequency of resource use at individual level, C_H = frequency of resource use at household level, C_C = frequency of resource use at community level, C_G = frequency of resource use at government level, and N = total number of adaptation strategies.

Results

Understanding local perception of climate change and disasters

The local people observed climate changes sign in the study area. Figure 3*a* indicated that 75% people were observed changes sign in Kurigram district, whereas 82% people observed changes in Nilphamari districts. Nearly 77 and 80% people were observed changes sign in Gaibandha and Panchaghar district respectively. On the other hand, local people observation with no changes was smaller than the observed changes, 20, 12, 5, and 10% respectively in those districts (Figure 3*a*). In addition, 2 to 5% of respondents were not aware about any changes, therefore unable to comment on it.

Besides climate change, local people also observed disaster incidents in the study areas. Figure 3b represented the percentage of people noticed disaster incidents in study area. Kurigram district was recorded for the highest number of riverbank erosion incident (74%). Nilphamari district was detected for the highest number of drought incident (74%). Nearly 90% of people were claimed cold wave was the most prominent disaster in Panchagarh district. Gaibandha district has been observed for the highest number of

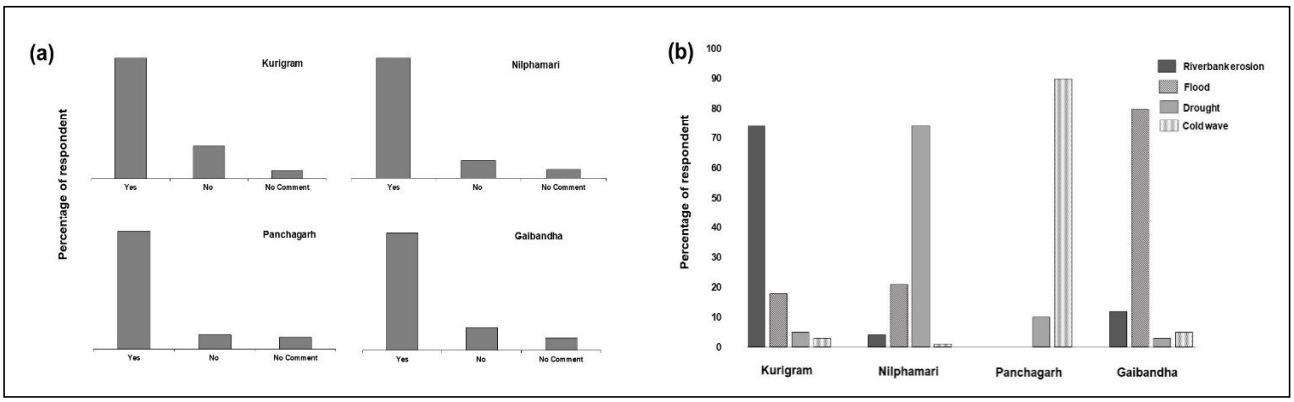

Figure 3. Percentage of respondent observed climate changes sign (a) and disaster incidents (b) in the northern Bangladesh (Source: Field survey)

Table 1

Percentage of livelihood resources in the northern Bangladesh

Resource	Kurigram (%)	Nilphamari (%)	Panchagarh (%)	Gaibandha (%)
Agricultural land	73	64	53	58
Human resources	8	10	7	8
Livestock	10	13	11	13
Fisheries	3	5	8	9
Forest	2	4	8	8
Wetland	4	4	13	4

Source: Field survey

flood incident (80%).

Recognizing important livelihood resources

Varied livelihood resources were mentioned in study area including agricultural land, human resources, livestock, fisheries, forest, andwetlands (table 1). Approximately 53 to 73% of respondents were agreed with agricultural land as one of their key livelihood resource. Human resources, livestock, fisheries, forest, and wetlands were also considered as a livelihood resources with different percentage.

Using adaptation strategies to response to climate change influences

Local people adopted various adaptation strategies to response climate change in the northern Bangladesh by using available livelihood resources mentioned above. Table 2 summarized local adaptation strategies in the study area. Respondent identified in total 22 adaptation techniques under 6 livelihood resource categories which they were practicing frequently in their locality.

Identifying important livelihood resources and appropriate level of capacity

The indexed value for adaptation strategies differed across livelihood resources at different level of capacity. It is presented in Figure 4*a*. The indexed values for access to human resources and livestock were the highest, 30 and 24 respectively. The second major resource was agricultural land (22), then forest (20) and wetlands (20). The lowest value was calculated for fisheries resource (11).

The capacity level diagram that plots the average weighted score of the contributing capacity level to use of livelihood resources are shown in Figure 4*b*. The capacity index value was highest for government level (0.7), whereas it was lowest for household level (0.4). The capacity index was 0.5 and 0.6 for individual level and community level respectively.

Discussion

In the northern Bangladesh, most of the respondent observed climate change including increase temperature, late rainy season, decreasing the rate of rainfall, increasing the intensity of cold wave, increasing the rate of riverbank erosion, and prolonged fog in winter season. Of these, all of the respondents united in one point that they observed lack of rainfall when it was needed. There was no systematic way to understand seasonal differences there. In addition, natural characteristics of six different seasons were not clearly visible in the study areas. Similar observation was evident in occurring disaster. For instance, frequent riverbank erosion, drought, flood and cold wave were observed in Kurigram, Nilphamari, Gaibandha and Panchagarh district respectively. This was entirely validated with previous information available on disaster occurrences in those districts. It was very interesting that none indicated about flood occurrence in Panchagarh as it was located in highland and considered as a flood free zone compared to other areas in the northern Bangladesh. There was no riverbank erosion occurred in the district too. The results demonstrated that people perception of climate change and disaster incidents varied due to different districts considered in the present study.

In addition, local people clearly understood livelihood resources, which they belonged to perform adaptation strategies in changing conditions. The livelihood resources also varied in four districts. This indicates an uneven distribution of livelihood resources across districts. For instance, landless people in Nilphamari district processed different adaptation strategies. Though the present study focused adaptation strategies based on available livelihood resources, still many strategies need to be incorporated for the vulnerable people who had no resource.

Table 2

Adaptation strategies based on livelihood resources in the northern Bangladesh

Livelihood resources	Adaptation strategies
Agricultural land	Cultivate diversified crops
	Using indigenous knowledge to understand soil condition
	Having sufficient irrigation facilities
	Using indigenous knowledge for information
	Accessing post-disaster land rehabilitation
Human resources	Having diversified employment opportunities
	Having better health and education
	Migrating other places in lean season
	Balancing gender issues
	Developing infrastructure
Livestock	Taking care of existing livestock
	Getting information from extension officers
	Having disaster preparedness to save livestock
Fisheries	Accessing fish variety and commercial fishing
	Digging more ponds for fishing
	Using locally available skills
Forest/Trees	Having space for forestry
	Maintaining value trees
	Homestead gardening
Wetlands	Maintaining and utilizing wetland appropriately
	Preserving rainwater
	Protecting wetland from sand and pollution

Source: Field survey

The present study considered adaptation strategies, which were frequent in all four districts (Table 2). However, strategies may differ because of local circumstances in those districts. For example, local people took several initiatives to protect agricultural land due to riverbank erosion and flood in Kurigram and Gaibandha district whereas there was no flood and riverbank erosion in Panchagarh district. Frequent flood damaged agriculture crops every year in Gaibandha district. Similarly, excessive cold wave hampered crop quality in Panchagarh. Agricultural land was found useless in many areas of Nilphamari district for unfavorable drought condition. Another example was fisheries resources, which received critical responses in the study area. During rainy season, there was a plenty of fish but lack of fishes was observed in dry season in Niphamari district. Fishes were frequently migrated during flood season in Gaibandha districts, hence contributed less in strategies in the district. These demonstrated adaptation strategies differed due to local circumstances. However, maximum concise dimension was considered with high level of attention to standardize adaptation strategies based on local people responses and capacity level.

The present study also demonstrated the impor-

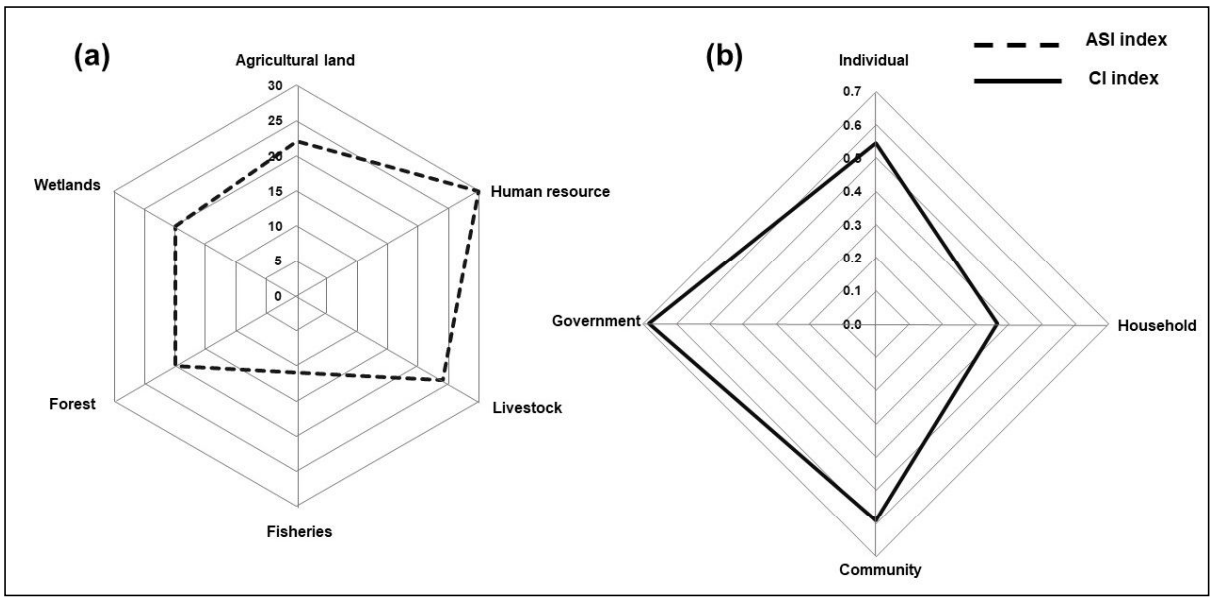

Figure 4. Important livlihood resources of the apatation strategy index (a), and the dimention of the capacity level (b). Source: Field survey

tance of capacity level, which determines the maximum use of livelihood resources in the study area. Several studies indicated that community based adaption effectively contribute to response climate change [24]. However, present study identified government level capacity would be the most influential. Other capacity levels (individual, household) were as important as government level. In general, combining all levels will eventually provide the greatest support to use of livelihood resources in study area to combat climate change influences.

Conclusion

The present study is focused on climate change perception, recognize important livelihood resources, and identify varied capacity level to implement usual adaptation strategies in the northern Bangladesh. This indicates the need of access to adequate resources in taking effective strategies. In addition, the present study demonstrates the role of capacity levels to enhance the process of adaptation. Hence, policies and programs aimed at enhancing and strengthening the adaptation strategies of the local people need to consider livelihood resources and capacity levels critically. Adaptation commitments should be based on local circumstance, and regional requirements need to be fulfilled appropriately. These should be integrated into existing national development plans and processes as government level capacity was evident most prominent in the northern Bangladesh. However, the existing community-based adaptation in the northern Bangladesh needs to revise by considering other important levels. This requires the engagement of a wide range of stakeholders, individual vulnerable people, local governments, civil society, non-governmnetal organizations, and national policy makers. Future analysis should focus on model-based adaptation strategies by predicting climatic change conditions. It also demands a deep understanding of the existing vulnerability of individuals, households, communities, the institutional, political, physical and social environment in the northern Bangladesh in which local people live and survive.

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IMPACTS OF NATURAL DISASTERS ON FARMS AND FARMERS IN MALAYSIA

Muhammad Ali[1,2], Norsida Man[2]*, and Farrah Melissa Muharam[2]
[1]Department of Agricultural Extension, PMAS-Arid Agriculture University Rawalpindi, Pakistan
[2]Department of Agriculture Technology, Universiti Putra Malaysia, Malaysia
Email: norsida@upm.edu.my (*corresponding author)

Natural disasters particularly floods and land sliding in Malaysia are frequently caused by climate changes. The impacts are also faced by farms and farmers in the form of production loss, farm infrastructure and even on psychology of farmers. Consequently, agricultural sector is becoming more risky which would affect food security of the country. Current research was carried out to assess the level of impacts of natural disasters on farms and farmers in the last five years. The impact level was measured on the scale of low, medium and high. The respondents were 360 farmers who were selected through one of the probability sampling techniques. The results revealed that climate changes in the form of natural disasters highly destroyed farm production, crashed irrigation and drainage facilities, and negetively affected emotions and psychology of farmers. The study recommends that various agricultural players such as public and private organizations, researchers, academia, students and policy makers are required to ponder profoundly on the impacts level and formulate strategies to facilitate farmers and their farms.

Keywords: *agriculture, natural disasters, adaptation, climate change, Malaysia.*

Introduction

The intensity of natural disasters is increasing on account of climate changes at the global level. According to Sawada and Takasaki [9], Klomp and Hoogezand [6], natural catastrophes have adversely affected human lives, livelihood and socio-economic structure of both developing and developed world. Malaysia is one of the countries being affected by climate changes [1, 4]. In the context of Malaysia these climate changes are also a source of floods, land sliding and drought [8].

According to Shaari et al. [11], the history of Malaysia has witnessed numerous floods such as flood of 1965 adversely affected 300, 000 people. Likewise, the series of floods in 1996 caused damage of 97.8 mln dollars, damage of 0.35 mln dollars in 2000 and smash of 489 mln dollars in 2007, that not only affected physical infrastructure but also disturbed economic growth of the country [11]. Mustafa [8] further added that droughts were also part of history in Malaysia. The author mentioned that Sabah state faced severe absence of rainfall in 1998 which affected more than 7200 farming community; the national staple crop (paddy) were badly damaged; aggregate financial loss was approximately 87 mln Malaysian Ringgits (MYR). The author further narrated that the state of Malacca faced severe drought which affected availability of water and caused drying of dam in 1999.

Consequently, Malaysia has been facing various natural disasters due to climate changes adversely affecting common people, farmers and agricultural sector which are a point of concern for various stakeholders. That is why the present study was designed to examine level of impacts of natural disasters on farms and farmers in Malaysia. The findings would be useful for policy makers, public and private sectors, researchers and resource poor farmers to deeply concentrate on impact levels from the future lens and design measures to avoid farmers' losses.

Methodology

In order to evaluate impacts of natural disasters, 50 farmers were randomly selected as pre testing of the questionnaire design. These 50 respondents were excluded in the final administration of the research. After refinement of the questionnaire, 360 farmers were selected through multi stage cluster sampling technique, during the end of the year 2015 to mid of 2016. It was assumed that these farmers were either victims of natural disasters or prone to natural disasters. The respondents were informed about the objective of the study. After green signal to carry on research from the farmers, questions reflecting impacts of natural disasters on farmers and farmers during last 5 years were asked on the scale of low, medium and high. The data were gathered through the help of local enumerators who were trained in handling questions

and keeping the moral high of the respondents during face to face interview. Furthermore, statistical analysis was performed on SPSS (version 21) to generate survey statistics: frequency distribution, percentage, mean and standard deviation.

Results and Discussion

The level of impacts of natural disasters in the last five years from the lens of farmers are presented in Table. According to the findings, natural disasters had highly affected farm production (mean=2.57). In fact, farmers are always concerned about the farm production as it is the main source of livelihood. Additionally, farm production is also used at the domestic level such as wheat, rice, maize and other crops may act as staple crops and farmers rely on that crop till next harvest to feed and get feed. Xu et al. [12] stated that severe natural calamities had negetively impacted grain production in Jilin province of China. Thus, it demonstrates that farm production is being highly affected by meteorological changes.

Another high impact created by natural disasters were on irrigation and drainage with mean of 2.28. In this context, climate changes may create scarcity of water and damage irrigation and drainage facilities at the farm level. This issue could lead to less crop production and price hike of crops at the market level which could further exploit by middle men. Additionally, the frequent floods also smash the existing drainage infrastructure at the farm level. This problem also breed problem for the public sector and farming community to rebuild for future purposes. Therefore, farmers are sensitive about their irrigation and drainage facilities and any obstacle create hindrance in the flow of agricultural activities.

The next important impact of natural disasters were on emotion and psychology of farming community with mean value of 2.22. Before, during or after disaster, farmers keep thinking and become worried about their crops, livestock, assets, farm equipments and facilities and others. The loss of precious lives affect their emotions which indirectly affect food security. Internal or external pain further impact on overall agriculture sector. Farmers also lose their confidence about sowing of next crops, making good decisions and continue agriculture as a profession. The consequences could lead to food insecurity and socio-economic stability. Farmers can also shift to other professions or even may abandon this sector. However, still more work is required to deeply assess impact of natural disasters on health, emotions and psychology of farmers around the globe as this is an important issue from the current and future perspective.

Farm infrastructure is an important area where farmers invest to get good harvest. However, natural disasters had also ruined these facilities in the research area (mean=2.19). Smashing of farm infrastructure may increase in the long run if not planned properly to manage the likely risks. The intensity of floods or abrupt land sliding damaged farm infrastructure which hampered agricultural activities. So, farming community perceived this impact as between high to medium level consequences of natural disasters.

Similarly, facilities, equipments and machinery were also got affected on account of natural disasters (mean=2.03). The equipments and machinery are also facilitate agricultural activities and their disturbance or damage either slow down or halt the agricultural activities. Although, the level of impact is between medium to high but still farmers cannot afford their damage. If these are adversely damaged, then it is another burdon on the shoulder of farming community and may take some time to repair or purchase new one. Therefore, farmers also witnessed impact in the five last years.

Fertilizer, farm store and labor also faced negetive impacts but comparatively low with mean value of 1.89, 1.84 and 1.58 respectively. Less or unavailability of fertilizer at the time of need may further slow down or totaly disturb the agricultural process. This could lead to less production and good quality output. The issue may also bring attention of middlemen to further explot farming community and either sell on high price or create artificial shortage in the market. So, it seems that middlemen get advantage of these issues due to climate changes and ultimately, farmers are being badly affected. Farm store were also affected due to natural disasters.

The existing impact level were low which could be caused by different reasons. The first reason might be frequency of natural disasters and prior experience. Thus, timely information of frequent floods or likelihood of land sliding influenced farmers to build farm store on comparatively higher altitude. Another reason could be the intensity of floods during the last 5 years which may increase in the future on account of sudden climate changes. Another reason could be advisory services provided by agriculture extension staff to raise the level of farm store or timely prevent from occurance of catastrophes. Importantly, the local wisdom or knowledge being transfered from generation to generation could also saved the farm store to get damage. The layout and particular location to built farm store on the basis of local wisdom might prevented some of the farmers from being destroyed.

Labor were another important aspect which faced impacts of natural disasters. Although, the level

Table

The level of impact of natural disasters on farms and farmers in Malaysia over the past 5 years, survey conducted in 2015–2016

No.	Impact	Level (Percentage)			Mean	SD
		Level	Medium	High		
1.	Farm production	9.2	24.4	66.4	2.57	0.655
2.	Irrigation and drainage	18.9	34.7	46.4	2.28	0.761
3.	Emotion and Psychology	8.9	60.0	31.1	2.22	0.593
4.	Farm infrastructure	19.2	42.2	38.6	2.19	0.736
5.	Facilities, equipment and machinery	26.4	44.4	29.2	2.03	0.746
6.	Fertilizer	29.2	52.5	18.3	1.89	0.682
7.	Farm store	32.5	50.8	16.7	1.84	0.684
8.	Labor	54.4	33.6	11.9	1.58	0.696
				Overall Mean	**2.075**	0.694

was low but may escalate in the coming times. The reason could be availability of agriculture labor even in hard times. Indeed, labor is easily available on account of daily wages and comparatively good income as compared to neighbouring countries so, this point could facilitated different rural areas to tackle the natural disasters. However, the rate of labor or their daily wages usualy increase in the time of heavy floods and land sliding which could affect finance of farmers. Thus, there is a need to formualte advance starategies by public, private and other development oragizations to facilitate the farmers and decrease labor shortage or curb the labor wages particulalry at the time of natural disasters. Additionally, it can be concluded that farmers experinced both physical and psychological impacts on their farms and internal health (emotions and psychology). Finally, the overal level of impact of natural disasters on the basis of total average mean (2.075) were medium in the current scenario but this level may rise in the long run.

According to Baqutayan et al. [5], the big lesson of adverse impacts on farm infrastructure were from the big flood which occured in east cost of Malaysia and adversly affected total farm production and physical facilities at farms. Additionally, Shaffril et al. [10] cautioned that climate change is not for the current time but it is the future dilemma as well which affect socio-economic fabric, human lives and health of the inhabitants of Malaysia. Moreover, Lindell [7] highlighted that natural disasters leave not only physical impacts but also social as well. Shaffril et al. [10], Austin and Baharuddin [2] indicated that climate variations would not only affect socio economic conditions, lives, or health in the present time but also keep affecting in the future too. Importantly, the negetive impacts on the farmers specially resource poor farmers may be less frequent so, these should be observed closely [3].

Conclusion and Recommendations

All in all, the findings demonstrated that level of impact of natural disasters was high on farm production, irrigation, drainage, and emotion and psychology of farmers. Therefore, it is recommended that different stakeholders, particularly extension service providers, should assist farming community to manage the risks properly in order to avoid loss of production and farm infrastructure. Additionally, continuous mentoring of farmers is also required to avoid psychological and health related issues for better future of the country. For this purpose, special trainings programmes may be initiated by public and private sector to tackle psychological problems of farmers. In this way, impact level of natural disasters may be minimized and food security can be ensured at the national level.

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AN EVALUATION OF RISK ADAPTATION PRACTICES BY FARMERS IN MALAYSIA

Muhammad Ali[1,2], Norsida Man[2]*, Farrah Melissa Muharam[2]
[1]Department of Agricultural Extension, PMAS-Arid Agriculture University Rawalpindi, Pakistan
[2]Department of Agriculture Technology, Universiti Putra Malaysia, Malaysia
Email: norsida@upm.edu.my (*corresponding author)

Climate change is not only affecting agricultural sector but also driving farmers to manage agricultural risks through various adaptation practices at global level. Farming community of Malaysia is also facing climate threats and taking different adaptation measures to manage the risks. Therefore, quantitative research was conducted in four zones of states in which 360 farmers were randomly selected. The findings showed that main adaptation measures mentioned by farmers were advance savings, diversification of income and agricultural sources and weather advisories. The study recommends that farm insurance as adaptation measure should be promoted by public and private sectors exclusively by agricultural extension personnel to minimize risk on account of climate changes in Malaysia.

Keywords: *agricultural risk, adaptation, climate change, agricultural extension, Malaysia.*

Introduction

Climate change has brought changes in the agricultural sector and grabbed attention of various stakeholders to handle the issue through various adaptation techniques. Although, many of the adaptation technique except high technology based interventions are old and have been used throughout the globe. Niles et al. [19] highlighted that various adaptation measures are significant for farming community to handle climate changes. Alam et al. [1] also stressed the importance of awareness about adaptation techniques among farmers which could help planning of advance preparation. According to Castells-Quintana et al. [10], areas and farmers who are financially or agriculturally marginal and are exposed to higher risk might depict maladaptation. So, there are always physical and psychological impediments in the adoption and implementation of adaptation techniques.

In reality, climate change has started ruining agricultural resources, livelihood of farmers, and pushed farmers towards vicious cycle of poverty that is why farmers might implement less effective adaptation measures [11]. In this context, Ampaire et al. [3] suggested that hurdles in the execution of adaptation or adaptation policy may be reduced through development of active linkages among important stakeholders and their involvement.

According to Masud et al. [18], there is absence of exact adaptation policy or guidelines for farming community in Malaysia. However, it was assumed that farmers would be involved in execution of various adaptation measures to tackle climate change issue even the clear guidelines or policy do not exist. Cutting it short, the research was designed to evaluate various adaptation techniques used by farmers in the current scenario.

Data and Methods

The research was conducted through survey in four areas of Malaysia namely Pahang, Terengganu, Johor and Kedah. Although data were collected from 400 respondents, however, 40 questionnaires were excluded due to incomplete responses. So, multi stage cluster technique was used to gather data from 360 farmers. The respondents were told about the main objective of the research and their personal information would not be shared. The local enumerators assisted in data collection. Moreover, questionnaire was designed with the consultation of experts who made significant contribution. Later, the questionnaire was further refined by pre testing in the field situation by collecting data from 50 respondents. These farmers were not repeated for data collection in the final data collection stage. Furthermore, the Statistical Package for Social Sciences (Version 21) was used to analyze the data.

Results and Discussion

Climate change has not only changed the landscape of the world but also forced farming community to tackle the issue by adapting various measures. According to Brown et al. [9], farmers adopt an adapta-

tion technique if they witness the potential advantage from the pragmatic lens. The results of research in table depict that farmers were using different adaptation techniques to manage the agricultural risks on account of climate changes. Based on the results, most of the farmers were using advance savings as reported by 223 (61.9%) farmers. In this regard, Freeman et al. [13] stated that savings adapted by an individual act as anticipatory kind of adaptation. For example, the savings may help farmers to install blocks or any other hindrance to stop flood being enter into the farmers' field. The farmers may also use savings to buy agricultural inputs after natural catastrophe when the financial aid by public or development sector (NGO) may take time to receive by the farmers. The savings may also assist them to buy food or for medical emergencies. Thus, savings may act as precautionary adaptation measure.

Farmers also used diversification of income sources as adaptation measure as mentioned by 155 (43.1%) farmers. They took this measure as alternative source of income in case the crop has been failed, attacked by the insect/pest, drought condition, severe damage by the flood or land sliding or any other reason. Additionally, farmers get involve in off farm activities as adaptation strategy in order to cope with the natural threats [4]. So, diversification of income acts as effective adaptation measure for victims of natural disasters [6, 12, 14].

The next adaptation measure was agricultural diversification as pointed out by 147 (40.8%) of the farmers. According to Azam-Ali [7] and Kandulu et al. [15], agricultural diversification is the blend of various crop and livestock activities and viewed as commonly used and effective adaptation measure to reduce impacts of natural disasters. Additionally, these kinds of strategies help farmers feel secure and resilient [16]. Another adaptation practice disclosed by 110 numbers of farmers (30.6%) was weather updates. It could be worthy to mention that appropriate piece of information at the proper time in the form of meteorological update assist farming community to make good decision and good adaptation strategy [17]. According to Boansi et al. [8], proper skills, some knowledge and awareness are required by farmers to use adaptation strategy. They added that extension service providers empower and assist farming community to remain updated about climate changes, tackling agricultural risks and enhancing agricultural production in an efficient manner.

Involvement in low risk based agriculture as an adaptation practice was also unveiled by 26.1% (94) of the farmers. It actually shows risky attitude of farmers to stay away from involvement in high risk based agricultural activities. In this regard, Aslam et al. [5] conducted research in South Punjab of Pakistan and found that farmers adhered with livestock farming were exposed to higher risk on account of flood and droughts. Furthermore, the other adaptation techniques adopted were crop sharing, agriculture value addition, integrated farming, village level networks by 53 (14.7%), 52 (14.4%), 46 (12.8%) and 41 (11.4%) of farmers respectively. Although crop sharing as adaptation measure is not common yet in the research area but in the long run farmers could start it at mass level if, extension service providers promote and facilitate in this regard at national, regional and international level. Some of the farmers had adapted value addition of their products as precautionary measure. This exercise may be good if propagated properly among the farming community. Moreover, value addition is based on various activities which support agriculture value chain but the dilemma is that it is being threatened by climate changes.

The less common adaptation measures were pre harvesting strategies, agriculture insurance and sowing of traditional varieties with frequency and percentage of 18 (5%), 12 (3.3%) and 08 (2.2%) respectively. It would be important to mention that insurance of crops or and farms as well as growing of recommended varieties are effective adaptation measures. Similarly, some of the farmers (6.4%) were involved in other types of adaptation techniques such as alteration of agronomic practices (like sowing time, change of entire crop or crop variety), temporary migration and start of short term new business are name a few. On the other side of the coin, there were 70 (19.4%) farmers who were not using any adaptation technique in the research area. There could be many reasons for non-adoption of adaptation measures like less frequent extension services, none or less favorable attitude towards adaptation measures, high frequency or intensity of risk, previous bad experience or fear of failure. Therefore, the extension service providers should change behavior of farmers towards adoption of adaptation strategies as extension workers are considered as "agent of change".

Tun Oo et al. [21] stated that farmers pick adaptation measure on the basis of their socio-economic condition, ease of application in actual field and timely encouragement from agricultural extension staff. Importantly, Ali et al. [2] highlighted that there is a challenge for agricultural extension service providers to not only equipped for tackling climate change but also required to assist farmers in timely addressing the issue. Additionally, findings of research by Ombo-

Table

Risk adaptation practices in Malasia

Practices	Frequency (*)	Percentage
Advance savings	223	61.90
Diversification of income sources	155	43.10
Agriculture diversification	147	40.80
Through weather updates	110	30.6
Chosen low risk agriculture activities	94	26.10
Crop sharing	53	14.70
Agriculture value addition	52	14.40
Integrated farming	46	12.80
Through village level networks	41	11.40
Pre harvesting strategies	18	5.00
Farm insurance	12	3.30
Using traditional varieties	08	2.20
No methods being used	70	19.40
Any other	23	6.40

(*) More than one answer

goh et al. [20] in Africa (Kenya and Uganda) revealed that collective action has also become instrumental in the selection of adaptation measure. All in all, Malaysian as well as global farmers had adopted various adaptation measures in order to cope with the natural disasters.

Conclusion and Recommendations

The research was formulated to assess adaptation practices being practiced by farmers. The findings show that farmers used various adaptation techniques to tackle risk originated through climate changes. The main measures were advance savings, diversification of income sources and agriculture and weather updates. The important but less common adaptation techniques were insurance and changes in agronomic practices. Therefore, it is recommended that efforts are required to promote insurance at farmers' level particularly resource poor and resident of far flung areas by government and private financial institutions. Additionally, agricultural extension staff should actively participate to assist farmers in the insurance process. Lastly, extension staff as agent of change should bring more adaptation techniques in the knowledge of farmers which could help in minimizing impacts of climate changes.

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Правила оформления рукописи в журнале
«РЕГИОНАЛЬНЫЕ ПРОБЛЕМЫ»

1. Рукопись загружается на сайте журнала **rp.icarp-febras.ru** и высылается обычной почтой в 1 экз. **Бумажный носитель обязателен.**

Там же необходимо заключить договор с редакцией на публикацию статьи и размещение ее в Интернете, а также предоставить экспертное заключение учреждения, в котором выполнена работа.

2. Рекомендуем оформлять статью по рубрикам: актуальность (постановка проблемы), объект и методы, результаты исследования и их обсуждение, заключение, список литературы.

3. **На первой странице рукописи** в левом верхнем углу должен быть указан индекс по универсальной десятичной классификации (УДК). Затем по центру следует на русском и английском языках название статьи, инициалы и фамилии всех авторов, полное название организации, почтовый адрес, e-mail, аннотации и ключевые слова; текст.

4. Текст статьи должен быть набран в редакторе WinWord, шрифтом Times New Roman, 12 pt. Поля слева, сверху и снизу – 2,5 см, справа – не менее 1 см. Объем статьи не должен превышать **13 страниц текста,** напечатанного через **1,5 интервала**, включая список литературы, таблицы и рисунки. К публикации принимаются статьи на русском и английском языках.

5. Сокращения слов, кроме общепринятых, в рукописи не допускаются.

6. Формулы нумеруются в круглых скобках (2), **подстрочные примечания не допускаются**, необходимые разъяснения даются в тексте.

7. Цитируемая литература приводится отдельным списком, перечисляется по алфавиту (в тексте оформляется квадратными скобками и порядковым номером списка) и оформляется в соответствии с ГОСТом (не более 20 источников литературы).

8. В конце рукописи необходимо четко указать название учреждения, фамилию, имя, отчество, ученую степень, звание, а также адрес (с индексом) и телефон автора.

9. ***Таблицы должны иметь заголовки на русском и английском языках*** и сквозную порядковую нумерацию в пределах статьи, содержание их не должно дублировать текст.

10. Весь иллюстративный материал (графики, схемы, фотографии, карты) именуется рисунками и имеет сквозную порядковую нумерацию. Рисунки выполняются **в черно-белом цвете** в формате GIF, TIFF, JPEG, CDR, EPS, либо в Word (wmf) и представляются в виде отдельных файлов. Рисунки в текст не вставляются, но в тексте дается обозначение, где должен быть рисунок. ***Подписи к рисункам на русском и английском языках*** печатаются на отдельном листе с указанием фамилии автора и названия статьи. Фотографии (1 экз.) должны быть четко отпечатаны на белой бумаге без дефектов. От качества авторских оригиналов зависит качество иллюстраций в журнале.

Все материалы, опубликованные в журнале «Региональные проблемы», безгонорарные. Плата за их публикацию с авторов не взимается.

Адрес редакции: 679016, Биробиджан, ул. Шолом-Алейхема, 4. ИКАРП ДВО РАН, редакция журнала «Региональные проблемы». Ответственному секретарю Соловченкову С.А. Электронный адрес: **reg.probl@yandex.ru** с пометкой «Региональные проблемы».