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URGENT: Urban Resilience and Adaptation for India and Mongolia

Report on:
Lecture Material
Environment, Climate Change and Occupation Health

Partner number: P11
Jawaharlal Nehru University, New Delhi
India

Disclaimer

Environment, Climate Change and Occupational Health

Semester -III: July – December

Coordinator	Dr Nikunj Makwana
Credits	4 Credits
Lecturers	Dr Nikunj Makwana + Prof. P K Joshi
Level	M.A.
Host institution	Special Centre for Disaster Research (SCDR), Jawaharlal Nehru University, New Delhi
Course duration	One Semester [July - December]

Summary

This one full semester elective course provides the Master level students of Disaster Studies the basic understanding of environment, climate change and occupation health. It gives more emphasis on the occupation health related to on-site hazards, risks and disasters. Besides, it will also introduce students to health-related challenges due to environmental and climate change across the globe. The course will touch upon frameworks at international, national and sub-national contexts. The course includes individual assignments.

Target Student Audiences

Semester - III Students of M.A.

Prerequisites

- Nil

Aims and Objectives

This course has been designed with a view to help students in developing a comprehensive understanding and knowledge of importance of occupation health from the perspective of hazards and disasters. The course work and exercises would ensure capacity development to initiate immediate lifesaving response and awareness for the standard operating procedure to be following during variety of occupation health disasters in different sectors. The main objectives of the course are: (i) to help students in understanding spectral of health issues related to hazards and disasters at work; (ii) to comprehend measures and practices needed for reducing health related; and (iii) to identify and enumerate environment and climate change related health challenges in the India and other countries.

General Learning Outcomes:

By the end of the course, students will successfully:

- Understand the occupational health related hazards and disasters,
- Learn and appreciate occupational health services and their importance in disaster risk reduction and planning,
- Identify and visualize wide spectrum of the occupational health hazards and emerging environmental and climate change related health issues across sectors.

Indian Occupational Safety Scenario

Overview of Sessions and Teaching Methods

The course will be delivered through interactive approach of discussions and learning from text books and referring the original research papers as well as review papers to understand the subject, the way it is. The interactive sessions supported by case studies, videos, external links and exercises. It also refers to the latest publications for understanding the trend in the given discipline and its applications. Whenever possible other teaching methods will be adopted and practical sessions, field trips and other organizational visits will be arranged to enhance the learning experience.

Course Workload

The table below summarizes course workload distribution:

Activities	Learning outcomes	Assessment	Estimated workload (hours)	Self-Study (hours)
In-class activities				
Lectures and Presentations	Occupational Hazards - Physical Hazards, Chemical Hazards and Biological Hazards - Radiation Hazards - Psychological Hazards - Work Related Musculoskeletal Disorders -carpal tunnel syndrome CTS- Tendon pain disorders of the neck- back injuries - Indian Occupational Safety Scenario. (Mining Industry, Construction Industry, Forestry, Agriculture and Allied Sectors)	Mid Semester Examination	06	06
Lectures and Presentations	Concept and spectrum of health - functional units and activities of occupational health services, pre-employment and post-employment medical examinations - occupational related diseases, levels of prevention of diseases, notifiable occupational	Mid Semester Examination	08	08

	diseases - effects and prevention - cardio pulmonary resuscitation, audiometric tests, eye tests, vital function tests - Industrial toxicology, local, systemic and chronic effects, temporary and cumulative effects, carcinogens entry into human systems. + Agricultural respiratory hazards and diseases, + Corporate and office hazards – Diseases and Human Health			
Lectures and Presentations	Incident Recall Technique (IRT), disaster control, Job Safety Analysis (JSA), safety survey, safety inspection, safety sampling, Safety Audit. Concept of an accident, reportable and non-reportable accidents, unsafe act and condition - principles of accident prevention- Role of safety committee - Accident causation models - Cost of accident. Overall accident investigation process - Response to accidents, India reporting requirement, Planning document, Planning matrix, Investigators Kit, functions of investigator, four types of evidences, Records of accidents, accident reports.	Mid Semester Examination	06	06
Lectures and Presentations	Fire properties of solid, liquid and gases - fire spread - toxicity of products of combustion - theory of combustion and explosion- Sources of ignition - fire triangle - principles of fire extinguishing -active and passive fire protection systems - various classes of fires - types of fire extinguishers - Sprinkler-hydrants-stand pipes - special fire suppression systems.	End Semester Examination	08	08
Lectures and Presentations	Environmental health review of development policies and projects, Environmental safety regulations, Reducing the vulnerability of environmental health infrastructure, Research methods used in the field of environmental health		06	06
Lectures and Presentations	Climate Change and Health, Climate Adaptation for Human Health,	End Semester Examination	06	06

	Communicating Climate Change and Health; Effect of weather, climate variability and climate change on human health and population health; Mitigation and adaptation policies and measures in health and related sectors; Case studies. Concept and approach of One Health			
Independent work				
Individual Assignments	Industrial visits, deliver first aid and initiate immediate life-saving responses, Awareness regarding related SOPs, Trauma Care and Burn Response, Hazard mitigation strategies, Selected case studies	Individual Presentations	10	10
Total			***56***	***56***

Grading

The students' performance will be based on the following:

- Quizzes/Surprise Test – 10%
- Mid Semester Examination – 30%
- End Semester Examination – 50%
- Individual Assignments – 10%

Grade	Grade Point	FGPA	Class/Division
A+	9	8.5 and above	High First Class
A	8	7.5 and above but less than 8.5	Middle First Class
A-	7	6.5 and above but less than 7.5	Lower First Class
B+	6	5.5 and above but less than 6.5	High Second Class
B	5	4.5 and above but less than 5.5	Middle Second Class
B-	4	3.5 and above but less than 4.5	Lower Second Class
C+	3		
C	2		
C-	1		
F	0		

Course Schedule: **Semester-III: July - December**

Course Assignments

The Structure of Individual Assignments will be as follows:

- Conducting Interviews in the field.
- Review of research articles and working paper with given objectives.

Literature

- Climate Change and Human Health Risks and Responses (A.J. McMichael et al), WORLD HEALTH ORGANIZATION, GENEVA, 2003
- Levy, B., Wegman, D., Baron, S., & Sokas, R. (Eds.), Occupational and Environmental Health.: Oxford University Press. Retrieved 5 Mar. 2022, from https://oxford.universitypressscholarship.com/view/10.1093/oso/9780190662677.001.0001/oso-9780190662677.
- Yassi, A., Kjellström, T., Kok, T., & Guidotti, T. (2001-05-17). Action to Protect Health and the Environment. In Basic Environmental Health. : Oxford University Press. Retrieved 5 Mar. 2022, from https://oxford.universitypressscholarship.com/view/10.1093/acprof:oso/9780195135589.001.0001/acprof-9780195135589-chapter-12.
- Environmental Health, Fourth Edition by Dade W. Moeller, ISBN 9780674047402, Harvard University Press
- Handbook of Occupational Health and Safety, NSC Chicago, 1982
- Derek, James, "Fire Prevention Hand Book", Butter Worths and Company, London, 1986.
- Loss Prevention in Process Industries-Frank P. Less Butterworth-Hein UK 1990 (Vol.!, II Et III)
- The Factories Act 1948, Madras Book Agency, Chennai, 2000
- Health Aspects of Chemical, Biological and Radiological Hazards, Australian Disaster Resilience Handbook Collection
- Knowlton, K., Kulkarni, S., Azhar, G., Mavalankar, D., Jaiswal, A., Connolly, M., ... & Sanchez, L. (2014). Development and implementation of South Asia's first heat-health action plan in Ahmedabad (Gujarat, India). International journal of environmental research and public health, 11(4), 3473-3492.
- Food safety, climate change, and the role of WHO
- Broughton, E. (2005). The Bhopal disaster and its aftermath: a review. Environmental Health, 4(1), 6
- Dhara, V. R., & Dhara, R. (2002). The Union Carbide disaster in Bhopal: a review of health effects. Archives of Environmental Health: An International Journal, 57(5), 391-404.
- Linda Young Landesman, , Robyn R. Gershon, , Eric N. Gebbie, , and Alexis A. Merdjanoff, , "10. Occupational Health in Disasters", Landesman's Public Health Management of Disasters: The Practice Guide, 5th Edition
- WHO (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s.
- WHO EURO (2013). Climate change and health: a tool to estimate health and adaptation costs
- WHO/WMO (2012). Atlas of health and climate
- WHO (2012). Mainstreaming gender in health adaptation to climate change programmes
- WHO (2011). Gender, climate change and health
- World Health Organization. 1992. Our planet, our health: Report of WHO Commission on Health and Environment. Geneva, Switzerland: World Health Organization.

- 2021 WHO Health and Climate Change Survey Report
- COP26 Special Report on Climate Change and Health
- Compendium of WHO and other UN guidance on health and environment
- Guidance on mainstreaming biodiversity for nutrition and health, WHO Publication
- Connecting global priorities: biodiversity and human health: a state of knowledge review, WHO Publication
- WHO global strategy on health, environment and climate change: the transformation needed to improve lives and wellbeing sustainably through healthy environments
- Occupational safety and health in public health emergencies: A manual for protecting health workers and responders: Geneva: World Health Organization and the International Labour Office, 2018. License: CC BY-NC-SA 3.0 IGO.

Environment and Disasters
- inherently linked

P K Joshi PhD
Professor - School of Environmental Sciences
Chairperson - Special Centre for Disaster Research
Jawaharlal Nehru University, New Delhi
Email: pkjoshi@mail.jnu.ac.in

Terms

Environment

the surroundings or conditions in which a person, animal, or plant lives or operates.

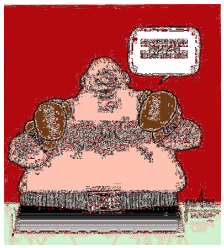
Disaster

a sudden accident or a natural catastrophe that causes great damage to resources or loss of life.

The Truth

Disasters are not random and do not occur by accident.

Hazard may!!



Cartoon: Rob Pudim (2014)

Frameworks (1)

"…have different points of departure but come to the similar conclusion that environment degradation, poverty, and disaster risk **share common causes** as well as **common consequences** for adverse effects on human security and well being."

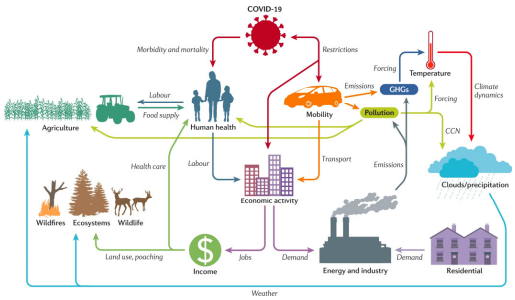
IDNDR International Decade For Natural Disaster Reduction (UN) · UNDRR UN Office for Disaster Risk Reduction · HFA Implementation of the Hyogo Framework for Action · SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015-2030

Frameworks (2)

"…also make clear that **ecosystem services**, **environmental management** & **environmental information** offer opportunities to reduce risk, decrease poverty and achieve sustainable development."

IDNDR International Decade For Natural Disaster Reduction (UN) · UNDRR UN Office for Disaster Risk Reduction · HFA Implementation of the Hyogo Framework for Action · SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015-2030

Earth Systems Response



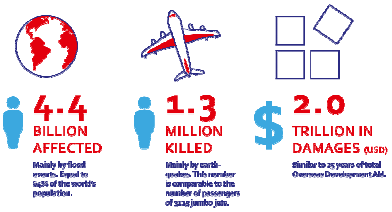
Source: Diffenbaugh et al. (2020)

Disaster Risk Reduction and Climate Change Adaptation

"Global Warming, Climate Change and Disaster Management - Future Perspective"
9th – 11th December 2019
@ TERI-SAS

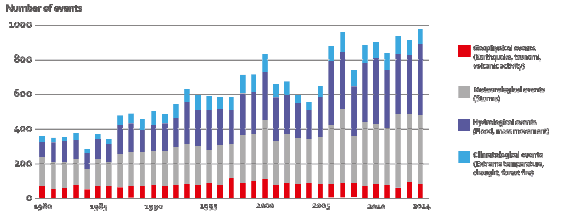
pk Joshi
Professor - School of Environmental Sciences (SES)
Chairperson - Special Center for Disaster Research (SCDR)
Jawaharlal Nehru University (JNU), New Delhi
Email: pkjoshi@mail.jnu.ac.in ; pkjoshi27@hotmail.com

Facts and figures



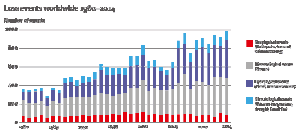
Facts and figures

Loss events worldwide 1980–2014



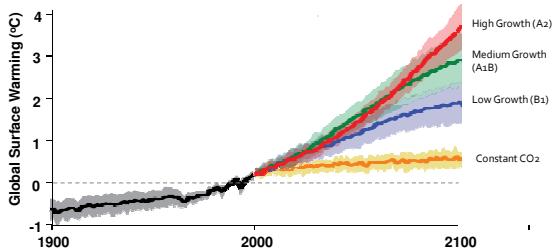
Source: 2015 Munchener Ruckversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE – January 2015

Facts and figures



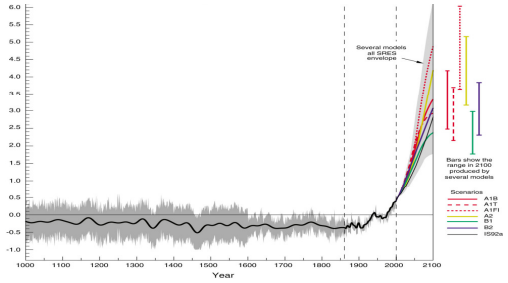
- The last 35 years show a steady increase in the number of disasters, mostly weather-related events (grey and blue bars) such as floods, storms or heatwaves.
- Climate change is increasing the number of weather-related hazards, a trend that is expected to continue.
- Geophysical events (red bars) have remained stable with a similar number of events throughout the years.
- The increase in loss events is attributable to an increase in disasters, and to the fact that more people and assets are exposed to the impacts of natural hazards.

Temperature Projections (21st Centaury)



Source: IPCC 2014

Temperature Projections (21st Centaury)



Source: IPCC 2014

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SHORT ARTICLE

Convergent Agency: Encouraging Transdisciplinary Approaches for Effective Climate Change Adaptation and Disaster Risk Reduction

América Bendito[1,2] · Edmundo Barrios[3]

Published online: 5 December 2016

Abstract Three recent global agreements have been established to facilitate the implementation of global-level responsibilities to deal with disaster risk reduction (DRR), human development, and climate change adaptation (CCA) respectively. While these agreements have a common goal of reducing social, economic, and environmental vulnerability, they have been developed by largely independent communities of practice. This has limited cross-fertilization despite the inherent multidimensional nature of global challenges and the considerable thematic overlap. We argue that developing a transdisciplinary strategy that effectively integrates disciplines, approaches, and knowledge systems will lead to greater and more sustainable impacts, together with a more efficient use of financial resources. Hybrid approaches should be encouraged during planning of future development efforts so that risk reduction is conducted simultaneously with CCA. Transdisciplinary processes are central to generating context-sensitive knowledge to support decisions on CCA and DRR options that minimize trade-offs and maximize synergies and complementarities required to guide sustainable development trajectories. Finally, building codes together with climate and risk-smart research, education, and awareness raising, are identified as priority entry points to materialize the blending of DRR and CCA approaches and effectively reduce risk while mitigating and adapting to climate change.

Keywords Building codes · Climate change adaptation · Disaster risk reduction · Sustainable development goals · Transdisciplinary knowledge

1 Introduction

For more than 25 years, the scientific community has been anticipating important global changes in the fields of climate change adaptation (CCA) and disaster risk reduction (DRR) following the release of the first assessment report of the Intergovernmental Panel on Climate Change (IPCC 1990). Since then a number of major global agreements and guidelines have taken place to address these issues (Fig. 1).

In 2015, three key global agreements were established to facilitate the implementation of global-level responsibilities to deal with DRR, human development, and CCA respectively (Fig. 1). In March, the Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR) (UNISDR 2015) replaced the Hyogo Framework for Action 2005–2015 (HFA) (UNISDR 2005). The SFDRR was designed to guide the international community in its collective support of regions and countries in strengthening their resilience to disasters. In September, the Millennium Development Goals (MDGs) were replaced by the Sustainable Development Goals (SDGs) (UN 2015), where DRR was addressed by goals linked to poverty eradication, food security, infrastructure, cities and human settlements, climate change, and ecosystems. Finally, in December, at the 21st Session of the Conference of the Parties (COP 21) of the United Nations Framework Convention on Climate

✉ América Bendito
americabendito@gmail.com

[1] Department of Civil Engineering, Universidad de Los Andes, Mérida 5101-A, Venezuela

[2] Independent Consultant, Nairobi, Kenya

[3] World Agroforestry Centre (ICRAF), P.O. Box 30677-00100, Nairobi, Kenya

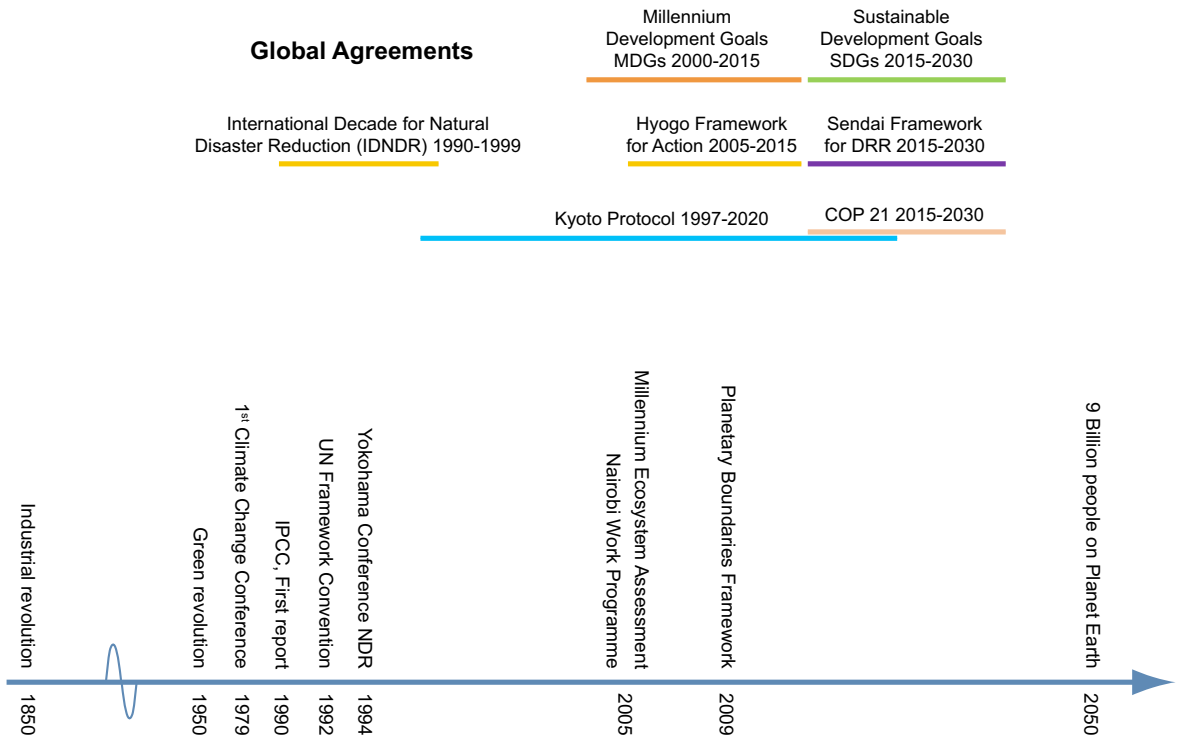

Fig. 1 Global initiatives in response to contemporary challenges on Planet Earth

Change (UNFCCC 2015), the draft of the Paris Agreement was adopted to address the immense challenges of climate change, hence facilitating government actions that encourage including risk reduction as part of efforts addressing CCA.

It is increasingly clear that these global efforts have overlapping goals. Developing a transdisciplinary strategy that effectively integrates disciplines, approaches, and knowledge systems will lead to greater and more sustainable impacts, together with a more efficient use of financial resources. This article briefly outlines areas of overlap, identifies priority entry points for collaborative engagement between the respective communities of practice, and proposes steps to guide the integration of DRR and CCA efforts to reduce vulnerability and increase their contribution to the SDGs.

2 Transdisciplinary Knowledge Contributes to more Effective DRR and CCA Actions

Developing transdisciplinary knowledge requires crossing multiple disciplinary boundaries, engaging scientific and nonscientific sources or practices, and using methodological tools that encourage collective learning (Barrios et al. 2012) from different disciplines to generate holistic understanding of global phenomena (Parkes et al. 2005; Stock and Burton 2011). In this section, we suggest a transdisciplinary process aimed at minimizing trade-offs, and maximizing synergies and complementarities between DRR and CCA efforts.

While efforts to reduce disaster risks and climate change risks have long coexisted, there is increasing recognition of the opportunities for blending CCA and DRR efforts because the types of actions required for both approaches are often similar (Doswald and Estrella 2015). Recognizing that climate change is a key hazard driver (Kelman 2015), for example, highlights the opportunity to explicitly incorporate the gradual effects of climate change when planning to reduce disaster risks.

When planning for DRR, traditional engineering options through structural approaches (reservoirs, dykes, seawalls, and dams), based on codes that do not take into account climate change, are normally the options considered. But when trying to adapt to climate change, ecosystem-based adaptation options are often considered, particularly in rural landscapes (Geneletti and Zardo 2016). We argue that both approaches should be strategically combined during planning of future development efforts so that adaptation to climate change is conducted simultaneously while reducing risks. The Dutch "Room for the River" program,[1] established in response to the devastating 1993 and 1995 Rhine delta floods in the Netherlands, is a good example of combining DRR and CCA approaches that aims to give rivers

[1] https://www.ruimtevoorderivier.nl/english/.

space to flood safely in order to protect vulnerable urban and rural areas. The success of convergent agency, however, is dependent on the full recognition of the advantages and disadvantages of both approaches, over different temporal and spatial scales, in order to develop a transdisciplinary knowledge that minimizes trade-offs and maximizes synergies and complementarities. Encouraging a gradual and open process of cross-fertilization would foster convergence, limit the risk that results of one approach negatively affect the results of the other, and more importantly ensure that the resulting development actions will help to reduce, and not exacerbate, vulnerability.

The lack of transdisciplinary knowledge to support recovery plans to face disaster events misses a great opportunity for reducing vulnerability to hazards and increasing adaptation capacity in the longer term. In El Salvador, for example, people who lost their homes to Hurricane Mitch in 1998 were still living in temporary shelters when an earthquake struck in 2001, thus leaving them even more vulnerable than before (Wisner 2001). The wrong location of provisional settlements following a disaster can also lead to unplanned environmental problems (for example, deforestation) that could limit the contribution of natural ecosystems to CCA (Parker et al. 1995).

Similarly, while mangrove forests normally occupy the costal intertidal zones and have been shown to reduce the impact of tsunami events (Danielsen et al. 2005; EEA 2015), their replacement with unsuitable vegetation to presumably provide the same protective function may actually lead to greater damage. For example, the planting of pine forests to prepare for coastal natural events along Japan's coast exacerbated damage during the tsunami caused by the Great East Japan Earthquake in 2011. Pine trees are inadequate for such protective function given their characteristic shallow rooting pattern, are uprooted more easily, and become the first debris to hit and damage houses and other buildings (Renaud and Murti 2013). The replacement of mangrove forests would also have an impact on the functionality of aquatic ecosystems given their important role as breeding grounds for fish and nursery habitat for their juveniles (Kathiresan and Bingham 2001). The failure to blend relevant scientific knowledge and local knowledge and experience has been highlighted as a common limitation to matching tree-based interventions to variations in social-ecological context (Coe et al. 2014).

In contrast, The Nature Conservancy has used transdisciplinary knowledge to guide DRR actions in the case of 1-in-100 year storm events in New York City, and concludes that hybrid options offer the best protection from these storms, while also providing significant environmental benefits (Nature Conservancy 2015). Hybrid options combine biodiversity conservation with engineering options tailored for key habitats (dunes, mangroves, coral reefs, wetlands, and forests). They benefit from and do not disrupt the natural features of these habitats, thus lowering vulnerability by reducing wave energy, absorbing floodwaters, and helping defend against storms. Hybrid options can also be used in urban settings to help cope with the effects of increasing mean temperature associated with climate change. For example, increasing tree cover in cities by encouraging tree planting along streets, in parks and backyards, together with the naturalization of lands that surround water and water facilities, can play an important role in buffering temperature through shading and maintaining moist environments (Bowler et al. 2010). While hybrid options have shown significant potential, there is still limited practical evidence of their success in simultaneously addressing the impacts of DRR and CCA. This is likely the result of difficulties encountered in the attempt to fully embrace transdisciplinarity during knowledge sharing and integration processes across different disciplines, sectors, and scales relevant for ecosystem management and DRR (Scholz and Steiner 2015).

3 The Strategic Role of Building Codes as an Entry Point to Reduce the Gap between CCA and DRR

Building codes create uniform regulatory standards that hold design professionals and contractors responsible to a set of principles aimed to protect families, communities, and society at large in the event of a natural hazard (FEMA 2013). The absence of building codes, outdated building codes, and the failure to enforce existing codes, all represent a fundamental vulnerability issue in urban and rural areas. The importance of building codes was highlighted by the dramatic contrast between the impacts of recent earthquakes in Haiti, Chile, and Japan. While the Haiti 2010 earthquake generated considerable human and structural losses because of the lack of building codes, the reduced impact observed after the Chile 2010 and Japan 2011 earthquakes was the result of the successful implementation of building codes that reduced human and economic losses. While the Chile earthquake released nearly 1000 times more energy than the earthquake in Haiti, both in densely populated areas, it resulted in 1000 times fewer victims (Bendito and Gutiérrez 2015). It is worrisome that following the West Java, Indonesia 2009 earthquake, new building reconstruction efforts did not follow the existing building codes (EERI 2009), thus increasing vulnerability by neglecting the Sendai Framework's Priority 4 that emphasizes the need of "building back better to prevent creating new risks" (UNISDR 2015).

Building code challenges go beyond urban settings and can directly influence food security. Postharvest losses are

recognized as one of the largest sources of inefficiency in agricultural production (IFAD 2013; CCAFS 2015). In Rwanda, for example, none of the postharvest facilities evaluated were designed with consideration of the emerging environmental and climate change challenges, nor were they constructed following building codes (Bendito and Twomlow 2014). While it is not viable to prevent self-construction, simple guidelines that include design, construction materials, and maintenance issues (Bendito and Twomlow 2014) can provide a significant contribution to transdisciplinary knowledge development processes that optimize hazard-resistance and ecosystem services in the self-constructed buildings.

Building codes should move from a passive to a proactive stance in order to maintain their relevance on a rapidly changing planet (Bendito and Gutiérrez 2015). Existing and new infrastructures should be better adapted to the current and expected future impacts of climate change. Building codes should therefore include, among other features, hazard maps developed for different events (multihazard maps) and for different engineering design levels (for example, differing return periods) (Bendito et al. 2014). Return period is the mean time between the occurrence of two specific hazards. Given the existing trend of increased frequency and intensity of climatic events, the current return periods (the probability of the most severe hazard event occurring in a 100-year period) used to develop hazard maps need to be revised to include shorter and multiple return periods.

Updated multihazard maps, data on exposure (building inventory, population size and distribution, soil types, and so on), ecosystem services (assessment of the degradation status of key habitats), Geographic Information Systems (GIS), and local knowledge (for example, early warning indicators) become critical components of risk maps as useful boundary objects during the development of transdisciplinary knowledge. Boundary objects are defined as collaborative products that can incorporate different points of view and still retain acceptable levels of robustness (Clark et al. 2011). Risk maps facilitate the communication of the spatial and temporal impacts of disasters on people, infrastructure, and ecosystem services by showing areas at high, medium, and low risk. Risk maps help to guide the development of mitigation and adaptation measures at different scales (for example, community, district, and national levels).

4 Transdisciplinary Knowledge to Reduce Gaps between DRR and CCA

The way in which findings are communicated in the global development arena can significantly influence outcomes because "words used are constructors of reality" (Mires 2015). If we continue to refer to human-made disasters as "natural disasters" people will continue to think that these disasters are acts of God and not caused by the increased vulnerability to hazards resulting from human actions. It is necessary to shift the perspective from natural disasters to "natural hazards" (Briceño 2015). We also have to make sure that these concepts exist globally in all cultures. In some African languages, for example, the term ''risk'' does not exist (Manyena 2016).

Developing transdisciplinary concepts that cut across the divides that mark traditional disciplinary boundaries can facilitate knowledge sharing and unification (Stock and Burton 2011). The Eco-Disaster Risk Reduction/Climate Change Adaptation (Eco-DRR/CCA) approach (Renaud et al. 2016) could be considered an effort to develop transdisciplinary knowledge. The Eco-DRR/CCA approach encourages the development of hybrid options by fostering the holistic thinking required to address complex problems synthesized in the SDGs. For example, when SDG 13 (Target 13.1) "strengthening resilience and adaptive capacity to climate-related hazards" is tackled using the Eco-DRR/CCA approach, Target 11.5 "reducing losses caused by disasters" and Target 6.6 "protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes" would also be directly influenced. Similarly, implementation of climate-smart postharvest projects as part of Eco DRR/CCA actions can simultaneously contribute to SDG 2 concerned with food security and improved nutrition, and SDG 9 concerned with building resilient infrastructure to foster sustainable development.

5 Conclusion

It is argued that DRR and CCA should be strategically combined during planning of future development efforts so that risk reduction is conducted simultaneously with adaptation to climate change. The ability of society to deal sensibly with risk and climate change, which largely occur together in time and space, would be strengthened with greater understanding of interactions between both phenomena. The value of transdisciplinary processes is shown to be central to research that generates context-sensitive knowledge to support decisions on CCA and DRR options that minimize trade-offs and maximize synergies and complementarities required to guide sustainable development trajectories.

Building codes are identified as a priority entry point to integrating DRR and CCA approaches. Climate- and risk-smart education and awareness raising should also be a fundamental component of the strategy to face our

increasingly unpredictable and challenging future. Universities need to improve undergraduate education teaching students to act locally while thinking globally, encouraging respect for diversity and the value of "deeper digging" through dialog and consensus building to fully benefit from processes of cross-fertilization. New engineering curricula need to seriously incorporate ecological knowledge as a resource rather than a burden, highlighting, for example, the strategic value of key habitats that act as natural solutions to reducing risk and vulnerability. Engineers would greatly benefit from a better understanding of the role of ecosystems and the multiple benefits they provide to society (ecosystem services) as great opportunities for convergent agency.

Acknowledgements We are grateful to Sálvano Briceño, Stephen Twomlow, and Arnaldo Gutiérrez for valuable comments that helped to improve this article. Funding to Edmundo Barrios to contribute to this article was partly provided by the CGIAR research programs on Forests, Trees and Agroforestry (FTA).

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Barrios, E., H.L.C. Coutinho, and C.A.B. Medeiros. 2012. InPaC-S: Participatory knowledge integration on indicators of soil quality—Methodological guide. Nairobi: World Agroforestry Centre (ICRAF), Embrapa, and International Center for Tropical Agriculture (CIAT). http://www.worldagroforestry.org/downloads/publications/PDFs/B17459.PDF. Accessed 8 April 2016.

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Bendito, A., J. Rozelle, and D. Bausch. 2014. Assessing potential earthquake loss in Mérida State, Venezuela using Hazus. *International Journal of Disaster Risk Science* 5(3): 176–191.

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CO-ACTION PUBLISHING

Health impact of climate change on occupational health and productivity in Thailand

Uma Langkulsen, Nuntavarn Vichit-Vadakan* and Sasitorn Taptagaporn

Faculty of Public Health, Thammasat University, Rangsit Campus, Pathumthani, Thailand

Background: The rise in global temperature is well documented. Changes in temperature lead to increases in heat exposure, which may impact health ranging from mild heat rashes to deadly heat stroke. Heat exposure can also aggravate several chronic diseases including cardiovascular and respiratory disease.

Objective: This study examined the relationship between climate condition and health status and productivity in two main categories of the occupational setting – where one setting involves heat generated from the industry and the other with heat in a natural setting.

Design: This cross-sectional study included four industrial sites (pottery industry, power plant, knife industry, and construction site) and one agricultural site in the Pathumthani and Ayutthaya provinces. Exposure data were comprised of meteorological data and heat exposure including relative humidity (RH) measured by Wet Bulb Globe Temperature (WBGT) monitor. Heat index was calculated to measure the effects of heat exposure on the study population, which consisted of 21 workers at five worksites; a questionnaire was also used to collect data on workers.

Results: Among the five workplaces, the outdoor WBGT was found to be highest at 34.6°C during 12:00 and 1:00 PM at the agricultural site. It was found that four out of five study sites had heat indices in the 'extreme caution,' where heat cramp and exhaustion may be possible and one site showed a value of 41°C that falls into the category of 'danger,' where sunstroke and heat exhaustion are likely and prolonged exposure may lead to heatstroke. Productivity as perceived by the workers revealed that only the construction and pottery industry workers had a loss of productivity ranged from 10 to 60 %.

Conclusions: Climate conditions in Thailand potentially affect both the health and productivity in occupational settings.

Keywords: *climate change*; *occupational health*; *productivity*; *heat index*; *WBGT*

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Previous studies regarding illness due to heat are minimal due to many reasons. Since high temperature is the norm in Thailand, diagnosis of illness or categorizing causes of death often overlooks heat as a contributing factor. There have been reports of heat stroke among soldiers who receive basic training (1). Heat stroke that leads to serious illness or death in Thailand has been found sporadically for athletes in the marathon and, since 1987, there are reports of soldiers become severely ill with high fever and symptoms of system failures such as cardiovascular, circulatory, respiratory, ingestion system, as well as blood coagulation, decreased platelets, acute renal failure, and even death and these cases have been diagnosed by physicians as exertional heat stroke (2).

Falling ill from the exercise is often found in the Thai military. Pilot studies by the researchers from the Phramongkutklao Hospital with the 1st Infantry Regiment (King's Bodyguards) applied heat index (HI) values as preventive measures for heat stroke during training similarly as in the US Army in Europe, Australia (3). The results showed HI values proved to be satisfactory and effective in reducing the dangers of heat stroke during military training.

In the academic arena, only a small number of studies have been done on the effects of climate change and most have dealt with environmental impact with some focus on the subsequent effects on the health of the population at large. Studies on the impact on occupational health have been sparse with an indirect reference to the effects of

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climate change. Searching through the electronic databases of research literature that may have some reference to the effects of climate change on occupational health, few studies investigated the effects of heat in an occupational setting. Three studies have found similar results showing physiological differences in cardiovascular loading during work performance between Thai workers and their western counterparts where the heart rate of the Thai workers could be 25–30% higher than the Europeans at equal levels of oxygen consumption (4–6). These physiological differences among the Thai workers are suggestive of a review of Thailand's own standards; that is, thermal standards where the Wet Bulb Globe Temperature (WBGT) limit is similar to the American Conference of Governmental Industrial Hygienists (ACGIH) (7, 8). However, one study (9) showed that the incremental heart rate (IHR) in the subjects while performing heavy, moderate, and light work load were related to the WBGT HI. Results of these few studies highlight the need for further study.

Furthermore, some studies showed that exercise and heat stress induced higher heart rate and blood pressure in sedentary subjects (10). Previous studies indicated that the relationship exists between data of the interval between two ventricular depolarizations (R-R interval) deviation of the electrocardiography (ECG) and temperature environment during daily living and work for people living around Bangkok in Thailand (11). A study of Thai industries reported heat problems existed in 24% of small enterprises (12).

Thai media gives attention to the issue of climate change where articles including global warming and impact on health appear in several Thai newspapers periodically. These articles cover diverse topics ranging from academic research on health effects, clinical studies in heat stroke patients (13–21), adverse health effects from physical hazards in Thailand (22, 23), prevention and relief (24, 25) as well as policy issues, and policy strategies to reduce deaths (26). Thermal stress may be assessed by several factors but temperature has become a widely used measurement, while the WBGT is a more specific occupational heat-stress index (27). Due to its acceptance in the monitoring and control of hot environment standards of the International Standards Organization (ISO 7243) (27), WBGT is often used in occupational health and safety guidelines for working in hot environments.

In Thailand, the Ministry of Industry (MOI) and the Ministry of Labor (MOL) have enacted compatible thermal standards using WBGT as indicators for thermal stress conditions in the workplace. Both ministries' occupational health and safety laws prescribe the same WBGT levels for workers working with light, medium, and heavy work of 34, 32, and 30°C, respectively (8). There is a report of WBGT measurements in several workplaces during a 3-year study (28). At a construction site, indoor WBGT was found to be 22–30°C during winter (November–December 1991). In three foundry industries, WBGT varied from 21 to 37°C from June to October of 1992. As expected, the summer season showed the highest WBGT measurements. The WBGT in two ceramics factories ranged from 20 to 33°C during the rainy season to winter (August–December 1992), while WBGT in two glass factories were found to be 27–34°C during winter (November–December 1992). In the sugar cane and rice fields where working outdoors predominates, WBGT was found to be 20°C–32°C during winter (January–February 1992) and 26–29°C during summer (March–May 1993). Those who work in industries that involve heat in its production were exposed to the higher heat level, but high levels were record in all workplaces including the agricultural sector.

Recognizing the importance of heat in the area of occupational health, mitigation programs have been introduced to reduce problems related to heat stress. Work Improvement in Small Enterprises (WISE) was implemented at a lamp manufacturer where environmental heat posed the possible problem of heat stress to Thai workers. The program aimed at improving the workers' productivity (29, 30). Similarly, the implementation of the participatory WIND (Work Improvement in Neighborhood Development) program led to concrete improvements in the daily work life of farmers (31). To narrow the gap in evidence that can be utilized for policy and mitigation measures development, this study provided information that can be used: (1) to analyze the effects of climate change on workers, and (2) to recommend appropriate/applicable cooling approaches for workers to prevent health impacts and to increase productivity.

Methods

Our study was descriptive in nature and aimed to examine the relationship between climate variables and health status in two main categories of an occupational setting where one setting involves heat generated from the industry and the other deals with heat in a natural setting. The data collection took place between September and October of 2009, which was considered the rainy season in Thailand when the temperature may not be in the highest annual range.

Selection of study location

The study focused on two provinces, Pathumthani and Ayutthaya, where there is a high concentration of factories as well as a well-established agricultural sector. These two provinces represented typical occupational settings with environmental conditions (high temperature and relative humidity – RH) that were the main interest of this study. Ayutthaya as well as Pathumthani, located

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in the central plains, experiences three seasons: the hot season from March to May, the rainy season from June to October, and the cool season from November to February.

Information gathering and data collection

Data collected for this study composed of both primary and secondary data, and the data collection period extended from October 5 to October 16, 2009. Data routinely collected related to the climate situation in Pathumthani and Ayutthaya. These data were collected by the Meteorological Department at Pathumthani and Ayutthaya meteorological stations and publicly available electronically.

The WBGT is a heat exposure index that combines temperature, humidity, wind speed, and heat radiation into one number expressed as degrees Celsius. It can be interpreted in terms of health risk and impact on productivity (32–34). The HI is a simpler index that combines air temperature and humidity (either the RH or the dew point – a measure of absolute humidity) (35). The relationship between these measurements provides a more scientific way to identify the health risks of heat than just temperature. The heat index chart gives some guidance on the heat categories and gives predictions as to the likelihood of heat illnesses in particular categories as shown in Table 1.

Primary data involved information pertaining to anthropometry data of the workers and the measurements of WBGT, RH, and workers productivity. The WBGT and humidity were measured by using QuestTemp° 34 equipment. The WBGT measurements were taken during five consecutive days from 6:00 AM to 6:00 PM at one point in the workplace such as the worksite area near a heat source.

Information on the workers' perception of their workplace environment and other related information were collected by face-to-face interviews. Questions included age, type of work or occupation, and heat stress. Information was also collected on how bad the heat stress can be in the hot season, as well as questions about the hot season heat affecting different aspects of the work. The questionnaire also contained questions concerning workers taking time off during the hotter parts of the day as well as the workers actions to reduce any heat effects.

Interview questions regarding productivity loss were asked about daily work output that could be quantified and how much work output can change as a result of heat. This study expressed productivity loss in terms of change of the daily work output. Daily work output was measured in terms of volume or quantity of items produced. Productivity loss was calculated as a change of daily work output using the formula:

$$\text{Productivity loss (\%)} = \left[\frac{\text{Change of daily work output as a result of heat (unit)}}{\text{Daily work output could be quantified (unit)}}\right] \times 100$$

Study population and sampling design

The study population consisted of workers at five worksites employed in industrial, agricultural, and construction sectors in Pathumthani and Ayutthaya. Types of industry include pottery industry, power plant, and knife industry. Purposive sampling was used in this study.

Exposure results

Since WBGT and RH measurements were monitored during the end of the rainy season, RH was very high or close to 100% in the early morning and decreased gradually after sunrise. WBGT was highest during 12:00 and 3:00 PM each day and can be expected to be much higher during summer. Among the five workplaces, outdoor WBGT was found to be highest at 34.6°C during 12:00 and 1:00 PM at Sam Khok vegetable field. The

Table 1. Heat index chart

Category	Heat index	Possible heat disorders for people in high risk groups
Extreme danger	130°F or higher (54°C or higher)	Heat stroke or sunstroke likely
Danger	105–129°F (41–54°C)	Sunstroke, muscle cramps, and/or heat exhaustion likely Heatstroke possible with prolonged exposure and/or physical activity
Extreme caution	90–105°F (32–41°C)	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity
Caution	80–90°F (27–32°C)	Fatigue possible with prolonged exposure and/or physical activity

Source: National Oceanic and Atmospheric Administration's National Weather Service (NOAA's NWS), U.S. Department of Commerce, 2009.

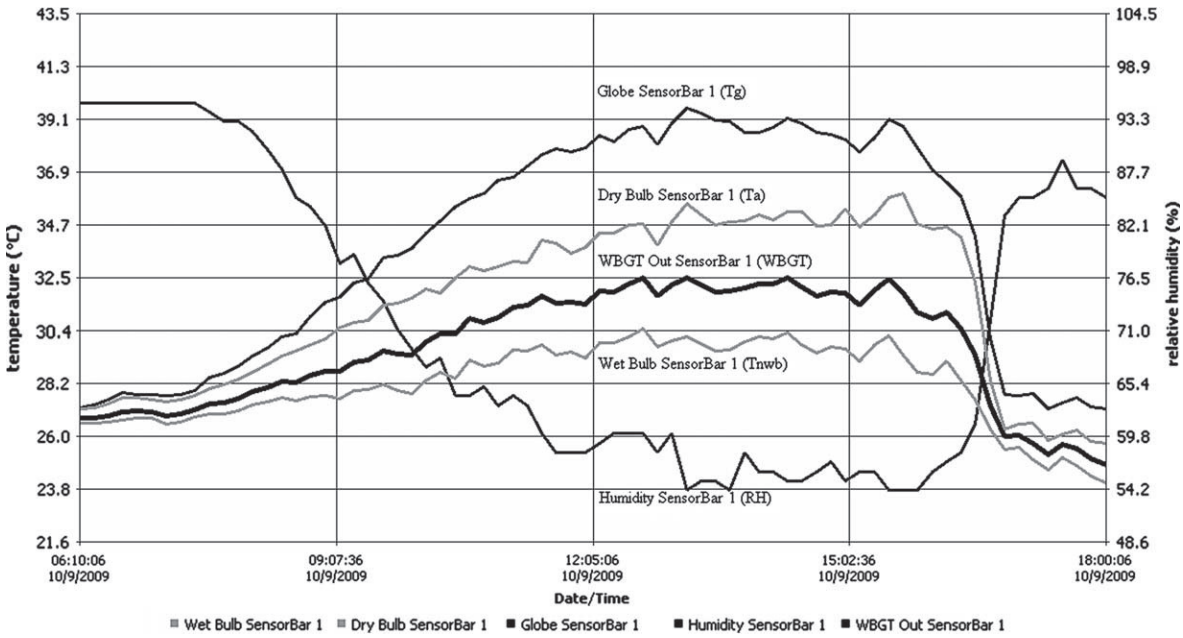

Fig. 1. WBGT, temperatures, and RH variation within 1 day at Sam Khok pottery industry.

results of heat exposure at five workplaces and a brief summary for each worksite are as follows.

Worksite 1: Sam Khok pottery industry

The outdoor WBGT data for one day, 6:00 AM to 6:00 PM, varied from 25.6 to 32.5°C with an average of 29.6°C as shown in Fig. 1. RH ranged from 54 to 95% with an average of 71.4%. The ambient temperature ranged from 26.1 to 35.9°C with an average of 31.5°C.

Worksite 2: Sam Khok vegetable field

The outdoor WBGT data for one day, 6:00 AM to 6:00 PM, varied from 25.2 to 34.6°C with an average of 30.7°C as shown in Fig. 2. RH ranged from 44 to 100% with an average of 60.0%. The ambient temperature ranged from 25.3 to 36.8°C with an average of 32.4°C.

Worksite 3: Ratchasuda construction building

The indoor WBGT data for one day, 6:00 AM to 6:00 PM, varied from 26.4 to 28.3°C with an average of

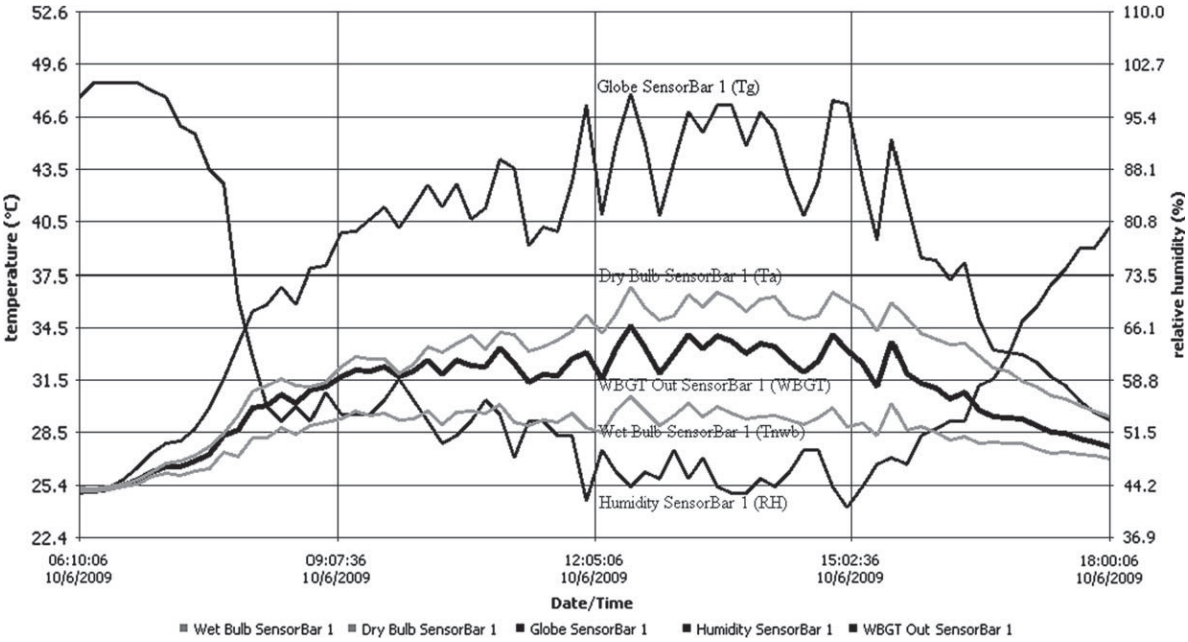

Fig. 2. WBGT, temperatures, and RH variation within 1 day at Sam Khok vegetable field.

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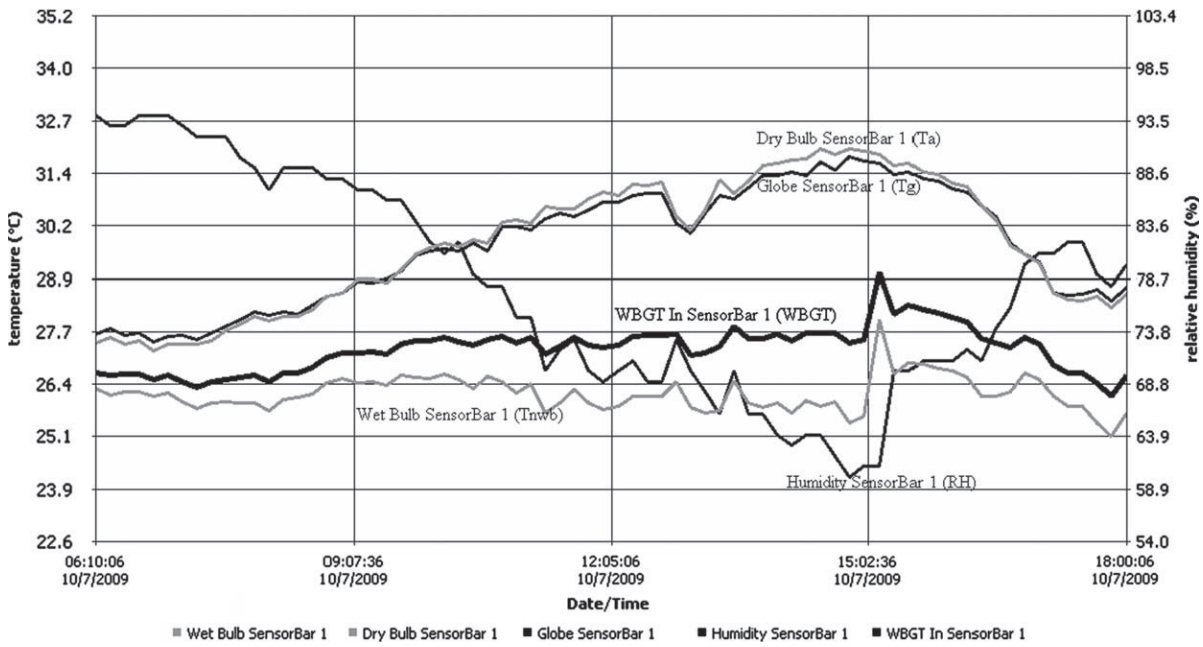

Fig. 3. WBGT, temperatures, and RH variation within 1 day at Ratchasuda construction building.

27.2°C as shown in Fig. 3. RH ranged from 64 to 93% with an average of 77.8%. The ambient temperature ranged from 27.4 to 32.0°C with an average of 29.7°C.

Worksite 4: Wang Noi power plant

The indoor WBGT data for one day, 6:00 AM to 6:00 PM, varied from 28.7 to 30.5°C with an average of 29.8°C as shown in Fig. 4. RH ranged from 54 to 75% with an average of 61.8%. The ambient temperature ranged from 31.1 to 35.3°C with an average of 33.6°C.

Worksite 5: Aranyik knife industry

The outdoor WBGT data for one day, 6:00 AM to 6:00 PM, varied from 25.5 to 29.6°C with an average of 27.7°C as shown in Fig. 5. RH ranged from 73 to 100% with an average of 84.1%. The ambient temperature ranged from 25.7 to 31.5°C with an average of 29.3°C.

Table 2 provides a summary of the heat exposure as measured by WBGT at the five workplaces during the study period. The vegetable field had the largest variation of WBGT – about 9°C within one day followed by the

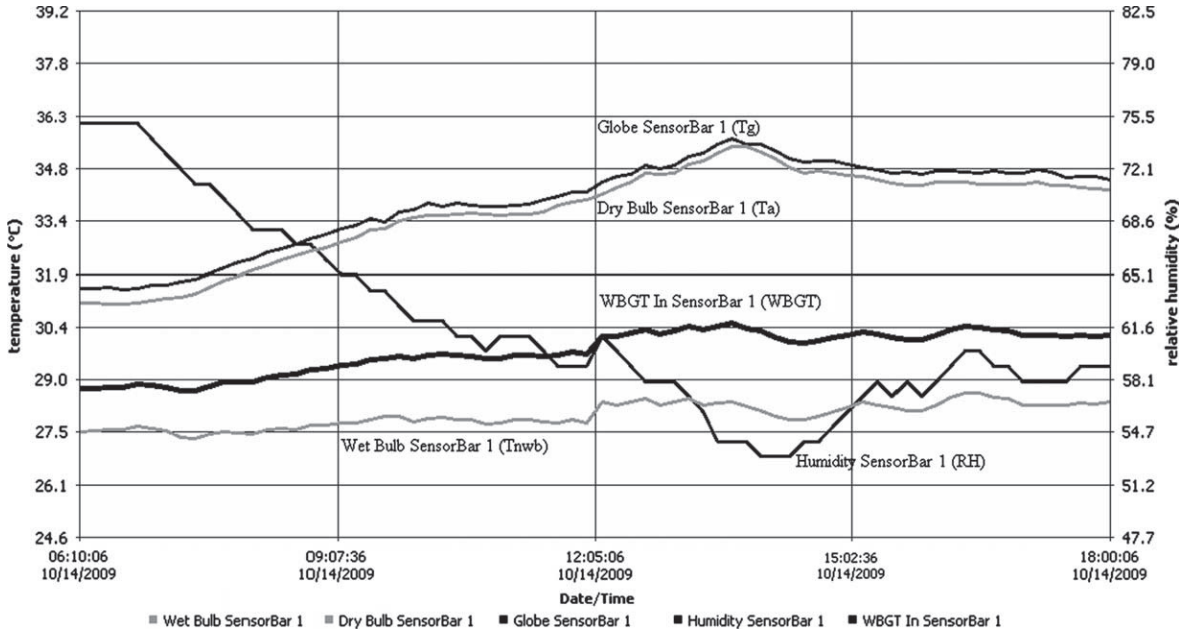

Fig. 4. WBGT, temperatures, and RH variation within 1 day at Wang Noi Power Plant.

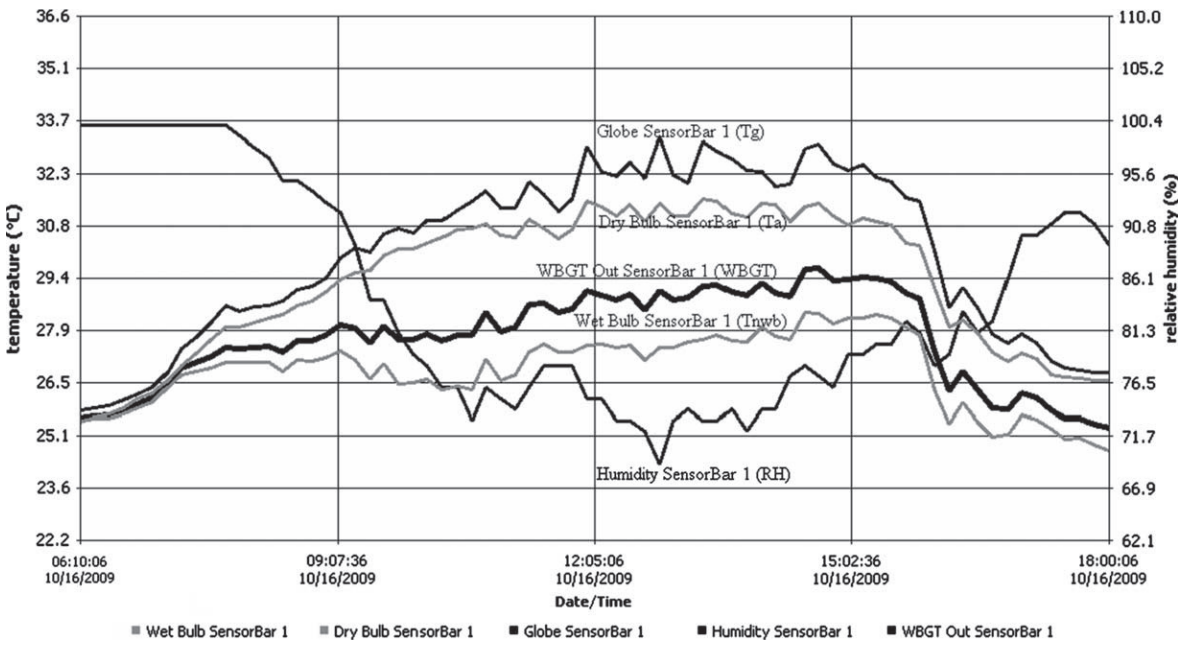

Fig. 5. WBGT, temperatures, and RH variation within 1 day at Aranyik knife industry.

pottery industry, knife industry, construction, and power plant. Interestingly, both vegetable fields and construction involved outdoor-related work activities but the vegetable field had a greater variation of WBGT. This may due to the surrounding environment of each place—the vegetable field was completely open to the sunlight, whereas the construction site may have structures providing shading areas.

Exposure-response estimation

In examining the HI for the five worksites in this study (Table 3), it was found that four out of five sites have HI in the 'extreme caution' where heat cramps and exhaustion may be possible. Closer examination of the HI for the power plant revealed that the value of 41°C may also fall into the category of 'danger,' where sunstroke and heat exhaustion were likely and prolonged exposure may lead to heatstroke. However, the risk of workers at the power plant being affected by this extreme heat may be minimal because most of the workers worked indoors with restricted involvement with outdoor activities.

Table 2. WBGT measurement data in five workplaces during October 2009

	WBGT (°C)
Sam Khok pottery industry	25.6–32.5
Sam Khok vegetable field	25.2–34.6
Ratchasuda construction building	26.4–28.3
Wang Noi power plant	28.7–30.5
Aranyik knife industry	25.5–29.6

Heat impacts and productivity loss

The production rate is presented as the productivity of the workers. Productivity loss is presented for each site for workers who reported a change of daily work output as a result of heat. Change of daily work outputs are compared with the measured values of the temperature, RH, WBGT, and HI as shown in Table 4. Vegetable field workers displayed no loss of productivity similar to workers in the knife industry, although the sample sizes were small. The information with regards to productivity as perceived by the workers revealed that only the construction and pottery industry workers assessed themselves with regards to loss of productivity. Two out of five (40%) pottery industry workers reported the average productivity loss per worker as 15%, while the others reported no loss of productivity. For construction workers, more than half (60%) the workers, productivity loss varied from 10 to 66.7%. However, daily

Table 3. Heat indices for the five workplaces

	Temperature (Celsius)	Relative humidity (%)	Heat index (Celsius)
Sam Khok pottery industry	31	72	38.4
Sam Khok vegetable field	31	65	36.6
Ratchasuda construction building	29	81	35.8
Wang Noi power plant	33	63	40.9
Aranyik knife industry	29	86	35.5

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Table 4. Exposure level and productivity loss

Exposure conditions				Type of work: industry						
				Workers[a]						
T (°C)	RH (%)	WBGT (°C)	HI (°C)	Age (yr)	Gender	Working hour (h)	Length of breaks (min)	Cooling actions	Productivity loss (%)	Working conditions
Worksite 1: Sam Khok pottery industry										
31.2	72.3	29.3	38.4	36	F	8	10	Shade, drink	20	Outdoors
31.2	72.3	29.3	38.4	39	F	8	10	Shade, drink, bath	10	Outdoors
31.2	72.3	29.3	38.4	39	M	8	5	None	No change	Outdoors
31.2	72.3	29.3	38.4	38	M	8	10	Shade, drink	No change	Outdoors
31.2	72.3	29.3	38.4	32	F	8	5	Shade, drink	No change	Outdoors
Worksite 2: Sam Khok vegetable field							Type of work: agriculture			
31.3	65.2	30.1	36.6	58	F	6	120	Shade, drink	No change	Outdoors
31.3	65.2	30.1	36.6	49	M	6	90	Shade, bath	No change	Outdoors
Worksite 3: Ratchasuda construction building							Type of work: construction			
29.3	81.0	27.1	35.8	27	M	8	60	AC, drink	No change	Indoors
29.3	81.0	27.1	35.8	35	M	9	10	Shade	66.7	Indoors
29.3	81.0	27.1	35.8	45	M	9	15	Shade, drink	40	Indoors
29.3	81.0	27.1	35.8	32	M	8	120	AC, drink	20	Indoors
29.3	81.0	27.1	35.8	63	M	8	10	Shade, fan	No change	Indoors
Worksite 4: Wang Noi Power Plant							Type of work: industry			
33.1	62.9	29.4	40.9	49	M	8	–	Fan, AC	N/A	Indoors
33.1	62.9	29.4	40.9	33	M	8	–	AC	N/A	Indoors
33.1	62.9	29.4	40.9	58	M	5	–	AC	N/A	Indoors
33.1	62.9	29.4	40.9	44	M	8	–	shade, AC	N/A	Indoors
33.1	62.9	29.4	40.9	40	M	7	20	Fan, AC	N/A	Indoors
33.1	62.9	29.4	40.9	45	M	7	15	Fan, drink	N/A	Indoors
Worksite 5: Aranyik knife industry							Type of work: industry			
28.8	85.6	27.3	35.5	76	M	3	30	Shade, drink	No change	Outdoors
28.8	85.6	27.3	35.5	43	F	4	60	Shade	No change	Outdoors
28.8	85.6	27.3	35.5	74	F	3	20	Shade, fan, drink	No change	Outdoors

[a]Productivity loss = change of daily work output as a result of heat; Working conditions of indoor = no direct sunlight exposure.
Note. T, temperature; RH, relative humidity; HI, heat index; M, male; F, female; AC, air conditioner; N/A, not applicable.

work outputs among power plant workers were not applicable.

Prevention methods

Prevention methods used to reduce heat exposure and effects at five worksites found that most workers reported consuming fluids as needed during the course of their work shift. Each worker noted that when they feel themselves becoming overheated, they would find a cool place to sit down and drink fluids.

Conclusion

This study may be viewed as a pilot study to examine the effects of occupational heat exposure on the health and productivity of the workers. Although the study involved only five worksites, the results elucidated us to the presence of heat exposure problems at the workplace and provided useful insights for further research in this area. This study documented the WBGT and HI in the different types of industries where heat may be a health hazard. Results in all five sites indicated working conditions that can be defined as 'extreme caution' or 'danger' where heat cramps, exhaustion, and heat stroke may be possible. Taking into account that the study took place during the rainy season when the temperature may not be its highest of the year, the occupational heat stress in the summer season when the temperature reached its maximum may pose even greater danger to the workers' health and productivity.

Priorities of the problems of heat exposure in an occupational setting should be placed on its health effects. Other impacts from heat exposure need to be highlighted as well. Thailand strives to be an emerging industrial economy where we have transformed ourselves from an agriculture economy for the last few decades. Consequently, industrial growth is placed on the national agenda in all the previous as well as the present government. Productivity rests at the core of this growth. As shown in this study, heat stress may reduce productivity of the workers. Although most workers have adapted themselves to heat exposure and have taken action to find relief, the government sector must consider heat as a health hazard along with other industrial pollutants that threatens the health of workers as well as the public.

The management of heat stress at the workplace requires efforts from all stakeholders and not placing the burden only on the employees themselves. The stakeholders should include the employer as well as responsible government agencies both at the local and central levels. Interviews with the governmental officer from the local health Center revealed that there is a lack of awareness with regards to policy concerning maximum heat exposure at work. Moreover, the impact of heat on workers health has not been considered as a priority by the Ministry of Public Health at the central level as stated by a key informant of the Bureau of Occupational and Environmental Diseases, Department of Disease Control. Our aim is to develop further, more detailed research on this public health issue.

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***Nuntavarn Vichit-Vadakan**
Faculty of Public Health
Thammasat University
Rangsit Campus
Tambol Klong Nueng
Amphur Klong Luang
Pathumthani 12121, Thailand
Tel: +662 986 9213 9 ext. 7449
Fax: +662 5162704
Email: nuntavarn@tu.ac.th

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The appended material is based on course revised/developed under the URGENT Project.

The course is being offered at the Jawaharlal Nehru University. The teaching is carried out using the published research material. As the course is multi-disciplinary, finding a text book is challenging. The appended notes are using the material available as Open Access, which is distributed under the terms and conditions of the Creative Commons Attribution license.

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