



# Climate Change Impacts on Food Security and Nutrition

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# Outline

- **Climate change impact to human health through food**
- **How to manage climate change impact to human health**
  - **Microbial ecology changes**
  - **Chemical use in Agriculture**
  - **Food safety management**
- **Recommendation**



# Health Effect due to Climate and Environmental Change

- Climate change
- Stratospheric ozone depletion
- Forest clearance and land cover change
- Land degradation and desertification
- Wetland loss
- Freshwater depletion and contamination
- Urbanization and its effects
- Damage to coastal reefs and ecosystem

## • Direct health effects

Floods, heatwaves, water shortage, landslides, exposure to ultraviolet radiation, exposure to pollutants

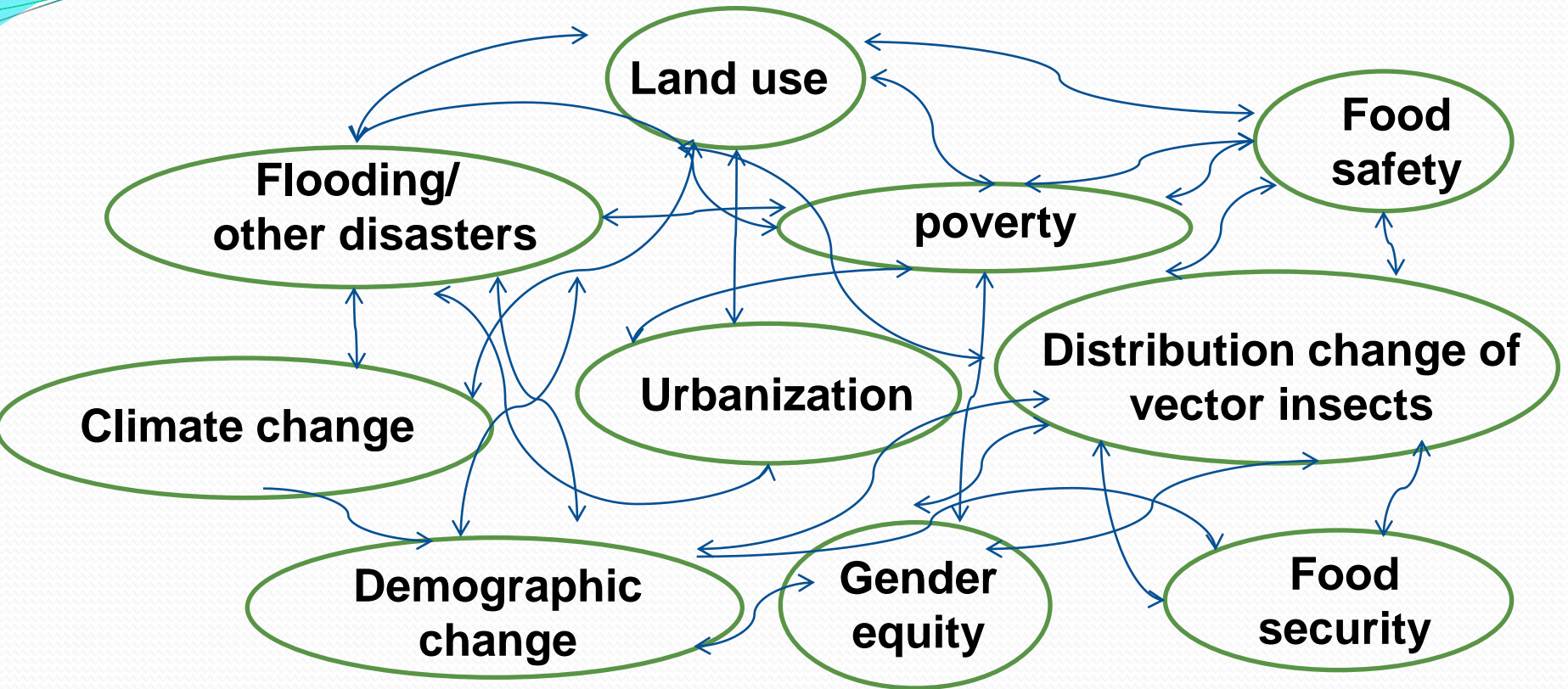
## • Ecosystem-mediated health effect

Altered infectious disease risk, reduced food yields (malnutrition, stunting), depletion of natural medicines, mental health (personal, community), effects of aesthetic or cultural impoverishment

## • Indirect, deferred, and displaced health effects

Diverse health consequence of livelihood less, population displacement (including slum dwelling), conflict, inappropriate adaptation and mitigation

# Inter-related Factors



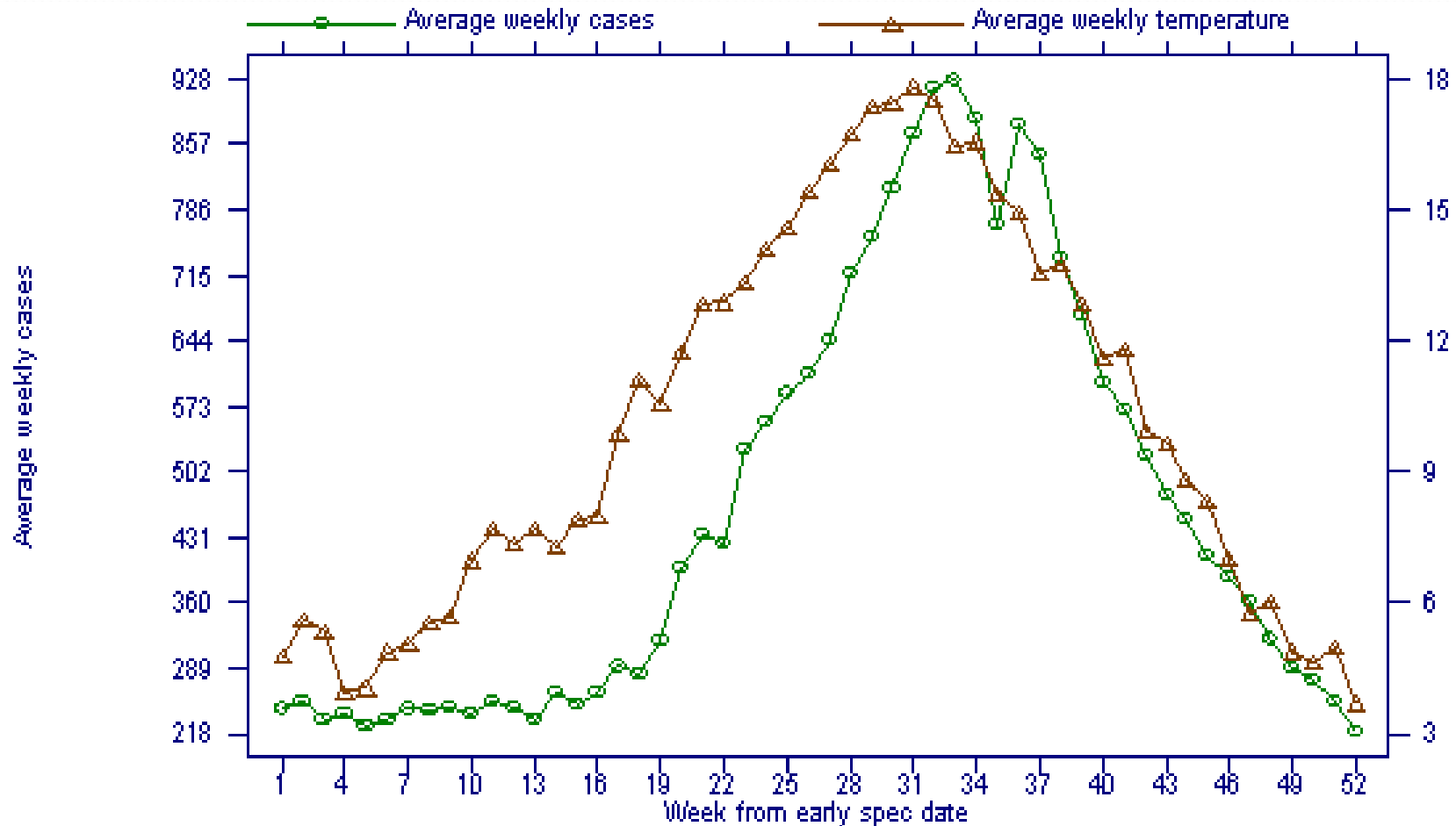
- Many factors are related each other and have impacts on human health and **FOOD SAFETY**

# Climate change effects on microbial ecology

- Losses of people and economics losses
- Consequences spreading of food and waterborne diseases e.g. gastroenteritis diseases frequently after flooding Salmonellosis and Vibriosis
- Elevated ambient temperature increased likely hood *Campylobacter* and *Salmonella* transmission.
- Seasonal variation in the cholera patients in Bangladesh can be explained by temperature and rainfall.

*Tirado et al. 2010. Climate Change and Food Safety: A Review. Food Res. Inter. 43:1745-1765.*

# Salmonellosis are preceded by weeks of elevated ambient temperature



(Kovats *et al*, 2003)

# **Seasonality and temperature effects on foodborne disease**

- **Salmonellosis associated with outdoor temperature when temperature greater than 7.5 °C**
- **Salmonellosis incidence in 5 cities in Australia (D'Souza *et al.*, 2003)**
- **a positive association between monthly Salmonellosis notifications and mean monthly temperature of the previous month.**
- **policy on food preparation and distribution.**
- **increase risk particularly from bacterial foodborne illness.**



# Climate change and impact on Food Handling Processing and Trading

- Risks associated with storage and distribution of food commodities.
- Reduced the availability and quality of water challenge to hygiene management.
- Higher temperature around the time of consumption are important and reinforce the need for further education on food handling behavior.

## FOOD SAFETY BEFORE, DURING AND AFTER A POWER OUTAGE

Know how to keep food safe before during and after emergencies. Hurricanes, tornadoes, winter weather and other events may cause power outages. Follow these tips to help minimize food loss and reduce your risk of foodborne illness.

### BEFORE PLAN AHEAD (IF YOU CAN) ...

- Put appliance thermometers in your refrigerator and freezer.
- Keep freezer **0°F** or below
- Refrigerator **40°F** or below
- Freeze containers of water and gel packs to help keep food cold if the power goes out.
- Group foods together in the freezer to help food stay colder longer.
- Freeze refrigerated items such as leftovers, milk, and fresh meat and poultry that you do not need immediately.
- If you think power will be out for an extended period of time, buy dry or block ice to keep the fridge or freezer cold.
- Store nonperishable foods on higher shelves to avoid flood water.

### DURING WHILE THE POWER IS OUT ...

- Keep the refrigerator and freezer doors closed to maintain cold temperature.
- IF DOORS STAY CLOSED ...
  - ... a full freezer will hold its temperature for **48 HOURS**
  - ... a half-full freezer will hold its temperature for **24 HOURS**
  - ... a fridge will keep food safe for **4 HOURS**

### AFTER ONCE THE POWER IS BACK ON ...

#### WHEN IN DOUBT, THROW IT OUT!

Check the temperature inside of your refrigerator and freezer. If they're still at safe temperatures, your food should be fine. Never taste food to determine its safety!

#### WHAT CAN I KEEP?

The following foods are safe if held above 40°F for more than 2 hours:

- Hard cheeses (Cheddar, Colby, Swiss, Parmesan, Provolone, Romano)
- Grated Parmesan, Romano or combination
- Butter or margarine
- Opened fruit juices
- Opened canned fruits
- Jelly, relish, taco sauce, mustard, ketchup, olives, pickles
- Worcestershire, soy, barbecue, and hot/sour sauces
- Peanut butter
- Opened single-serve dressings
- Bread, rolls, cakes, muffins, quick breads, tortillas
- Breakfast foods (bacon, pancakes, bagels)
- Fruit pies
- Fresh mushrooms, herbs, and spices
- Uncut raw vegetables and fruit

#### WHAT SHOULD I THROW OUT?

- Meat, poultry or seafood products
- Soft cheeses and shredded cheeses
- Milk, cream, yogurt, and other dairy products
- Opened baby formula
- Eggs and egg products
- Dough, cooked pasta
- Cooked or cut produce

REFREEZE FOOD THAT STILL CONTAINS ICE CRYSTALS OR IS AT 40°F OR BELOW.

### AFTER A FLOOD

#### FOLLOW THESE STEPS AFTER A FLOOD:

- DO NOT EAT any food that may have touched flood water.
- DISCARD FOOD not in waterproof containers; screw-caps, snap lids, pull tops, and crimped tops are not waterproof.
- DISCARD cardboard juice/milk/baby formula boxes and home canned foods.
- DISCARD any damaged cans that have swelling, leakage, punctures, holes, fractures, extensive deep rusting, or crushing/deforming severe enough to prevent normal stacking or opening.

**SANITIZE**  
1 tbsp. bleach + 1 gallon water

Pots, pans, dishes and utensils  
Undamaged all-metal cans after removing labels

USDA Ad Council FoodSafety.gov



# Climate change effects on water and food supplies

- Drought could reduce drinking water supplier and crop yields.
- Increase world food insecurity.
- Declining fisheries which contribute to protein shortage.
- Increased risks of food-borne illnesses.

**ประเด็นข่าวฮิต** ข่าวภัยแล้ง

สระเก็บน้ำในวัดอุโมงค์ เชียงใหม่ แท้ง ขอด เร่งขนย้ายปลาหนีตาย

สระน้ำความกว้างกว่า 7 ไร่ แดกลับมีน้ำเพียงก้นบ่อ จึงต้องช่วยกันขนย้ายปลานับพันตัว...



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ร้อนสุด	44.5	วัดอุโมงค์ เชียงใหม่
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# Other Potential Impacts of Climate Change on Food Safety

- Impacts on microbial evolution and stress response.
- Bacterial mechanisms allow them to survive and grow under unfavorable or “stressful” condition.
- Pathogens with documented stress tolerance responses (temperature, pH) such as:
  - enterohemorrhagic *E.coli*
  - *Salmonella*
  - *Listeria monocytogenes*.

## Survival of acid-stressed cell and non acid-stressed cell of *Listeria monocytogenes* after expose to lethal acid (pH3.5)

Exposure time (h)	<i>Listeria monocytogenes</i> count (Log CFU/ml) <sup>a</sup>	
	Acid-stressed cell	Non acid-stressed cell
0	4.72 ± 0.15 <sup>Aa</sup>	4.38 ± 0.56 <sup>Aa</sup>
0.5	4.05 ± 0.10 <sup>Ab</sup>	3.42 ± 0.15 <sup>Ba</sup>
1.0	3.04 ± 0.04 <sup>Ac</sup>	2.13 ± 0.19 <sup>Bb</sup>
1.5	2.00 ± 0.19 <sup>Ad</sup>	0.60 ± 0.51 <sup>Bc</sup>
3.0	ND <sup>Ae*</sup>	ND <sup>Ac</sup>
5.0	ND <sup>Ae</sup>	ND <sup>Ac</sup>

Pongkanpai, V., W. Makakarnchanakul and W. Garnjanagoonchorn. 2013. Acid and Heat Tolerance of Acid-stressed *Listeria monocytogenes* Inoculated in Broth and Shrimp Model. Journal of pure and applied microbiology. Vol. 7(2): 837-843

# Mycotoxins

## Moulds and mycotoxins of world-wide importance

Mould species		Mycotoxins produced
<i>Aspergillus</i>	<i>parasiticus</i> <i>flavus</i>	Aflatoxin B <sub>1</sub> B <sub>2</sub> G <sub>1</sub> G <sub>2</sub> Aflatoxin B <sub>1</sub> B <sub>2</sub>
<i>Fusarium</i>	<i>sporotrichiodes</i> <i>graminearum</i>  <i>moniforme</i> ( <i>verticillioides</i> )	T-2 toxin Deoxynivalenol (nivalenol) Zearalenone,  Fumonisin B <sub>1</sub>
<i>Penicillium</i>	<i>verrucosum</i>	Ochratoxin A
<i>Aspergillus</i>	<i>ochraceus</i>	Ochratoxin A



**Particular mycotoxins may cause  
carcinogenic,  
immunosuppressive,  
neurotoxic,  
estrogenic  
and teratogenic activity**



# Fusarium toxins in Maize

## ❖ *F. graminearum*

- ❖ predominate in the warmer temperature region (25-28 °C)
- ❖ produce either deoxynivalenol (DON) or nivalenol (NIV) and Zearalenone (ZEA)

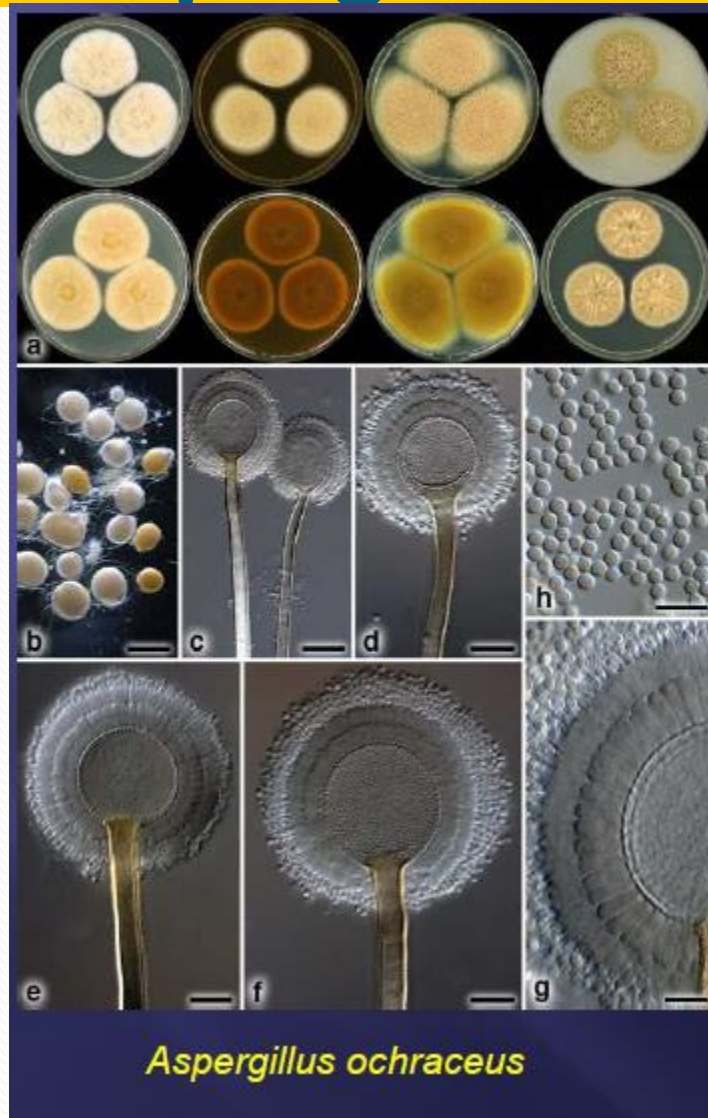
## ❖ *F. culmorum*

- ❖ more common in the cooler regions
- ❖ produce only DON and ZEA

❖ As a series of warm European summers the occurrence of *F.culmorum* is replaced by *F. graminearum*, the species that is more virulent plant pathogen .

❖ A shift to NIV/ZEA pattern from DON/ZEA pattern in Europe and Asia.

# The Yellow Aspergilli and ochratoxin



# Identification of the mould isolates from Thai coffee

- More than 1,000 isolates were obtained
- All these strains were grown on various agar media and examined by light and scanning electron microscopy
- Extracts of DNA were made from a selected number of strains and specific genes were analyzed.
- Extracts of colonies on media were made and the secondary metabolites were examined.
- All these data were analyzed and it was shown that two new species from Thailand were discovered.

Isolation, identification and toxigenic potential of ochratoxin ...

[orbit.dtu.dk/en/...and...of-ochratoxin...coffee.../export.html](https://orbit.dtu.dk/en/...and...of-ochratoxin...coffee.../export.html) ▼

Isolation, identification and toxigenic potential of ochratoxin A-producing *Aspergillus* species from coffee beans grown in two regions of Thailand. / Noonim, P.

*Aspergilli* and ochratoxin A in coffee. > Research Explorer

[https://pure.knaw.nl/...ochratoxin-a...coffee\(d86b3cd9.../export.html](https://pure.knaw.nl/...ochratoxin-a...coffee(d86b3cd9.../export.html) ▼

Noonim, O, Mahakamchanakul, W, Varga, J & Samson, RA 2008, 'Aspergilli and ochratoxin A in coffee.' in J Varga & RA Samson (eds), *Aspergillus in the ...*

Enumeration of Ochratoxin a Producing Fungi in Thai Coffee ...

[books.google.com/.../Enumeration\\_of\\_Ochratoxin\\_a\\_Producing\\_Fu.html?i...](https://books.google.com/.../Enumeration_of_Ochratoxin_a_Producing_Fu.html?i...)

Enumeration of Ochratoxin a Producing Fungi in Thai Coffee Beans. Front Cover. Paramee Noonim, Mahāwitthayālai Kasētsāt. Department of Food Science and ...

Paramee Noonim Kasetsart Univ. Dissertation  
2008

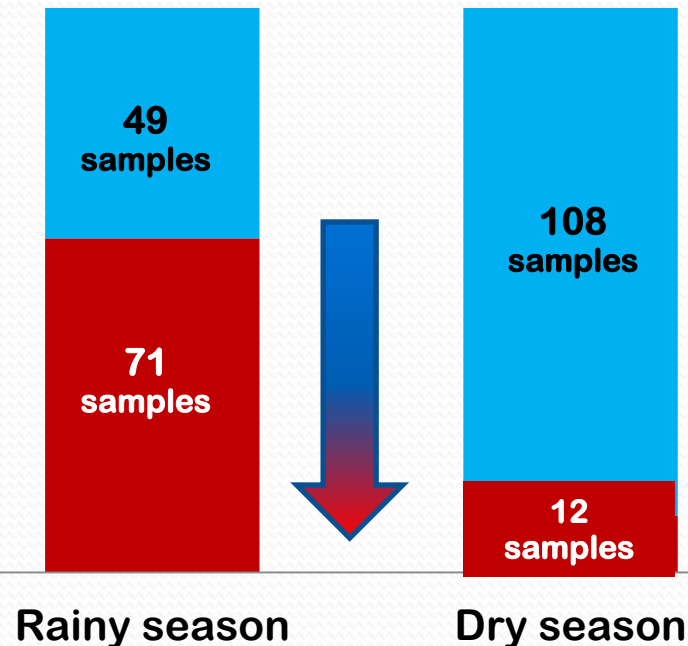




# Seasonal influence on the amount of AFB1 in brown rice



Not Detected AFB1  
positive AFB1



Iamtaweejaroen, P., P. Kooprasertying, T. Maneebun, N. Anukul. and W. Mahakarnchanakul. 2016. Exposure to aflatoxin B1 in Thailand by consumption of brown and color rice. Mycotoxin research 32(1): 19-25.

# Mycotoxins Control and Management



**Farming**



**Food  
processing**



**Finished  
product**

**GAP**



**GMP/HACCP**



**Standard  
Regulation**

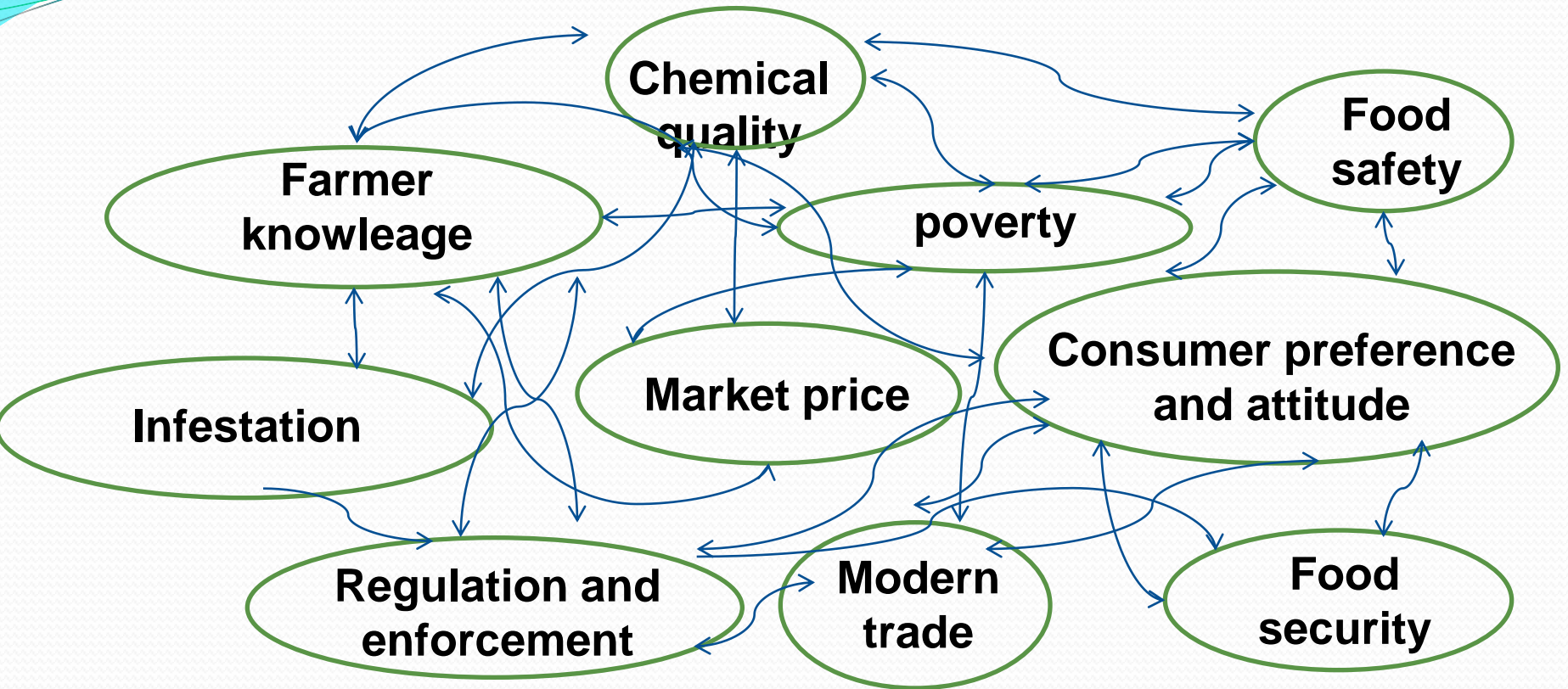


# Climate change and its impact on Agricultural

- **Crop production**

- direct → microbial population of soil, air and water
- direct → population of pests and vector
- indirect → the occurrence and diseases from fungi, bacteria, viruses and insects
- *Demand for the fertilizers may cause the higher trace impurity in crop .*
- *Demand for the organic produce may cause the problem of foodborne diseases due to consumption of fresh produce*
- *Increasing of pesticide application cause the residue in fresh produce.*
- And greater risks due to increase produce consumption.

# Inter-related Factors



- **Many factors are related each other and have impacts on human health and FOOD SAFETY**

## Government/WHO

- Responsibility and concern assurance food safety on short and long term
- Legislation not (yet) harmonized, less elaborated as compared to animal

## Climate change

- More variable and extreme weather condition
- Increasing temperature
- Excessive rainfall
- Consequence for food and waterborne diseases
- Consequences crop production areas and ecosystem

## Global change

- Shift demographic, social and economical conditions
- Towards world wide markets
- Global sourcing fresh produce
- Many movements and long distances in supply chains
- Increasing volumes, and new harvesting area

## Control and assurance of safe fresh produce

### Food safety management system (FSMS)

- Lack of effective control measure in place
- Lack of science-based defined FSMS
- Lack of scientific underpinned risk assessment on emerging pathogens (e.g. viruses)
- Lack of insight in effectiveness of FSMS

Control & assurance

## Fresh produce production chain

Crop production → Post harvest storage → Processing & packaging → Distribution & retail

- Fresh produce heavily exposed to environment
- Intrinsically high risk microbial contamination
- Lot of human handling
- Usually no (full) inactivation of pathogens (mild process)

Safe fresh produce

## Consumer trends

- Increase consumption (prepared) fresh produce
- Change in cooking practices (mild practices)
- Use of new ingredients but not same cooking practices
- Increase healthy fast foods based on fresh produce

**Fig Inventory of various conditions and developments which influence the vulnerability of fresh produce food chain( Jacxsens et al. 2010. Food Res. Inter. 43:1925-1935)**

วิภาวดี อันท้วม น้าทิพย์ ชันตยาภรณ์ และวราภา มหากาญจนกุล. 2553. ผลของอุณหภูมิเก็บรักษาต่อการรอดชีวิต ของ *Escherichia coli* และ *Salmonellae* ในปุ๋ยมูลสัตว์. ใน เรื่องเติมการประชุมทางวิชาการของมหาวิทยาลัยเกษตรศาสตร์ ครั้งที่ 48: สาขาอุตสาหกรรมเกษตรกรุงเทพ. มหาวิทยาลัยเกษตรศาสตร์. หน้า 401-40

# Survival of Mixed Pathogens in Dried Animal Fertilizers : *Salmonella* spp. and *Escherichia coli*



- *S. Hvittingfoss* + *E. coli*
- *S. Augustenborg* + *E. coli*

- 4 type of fertilizers

- (autoclaved) :

- Bat
- Hog
- Cattle
- Chicken

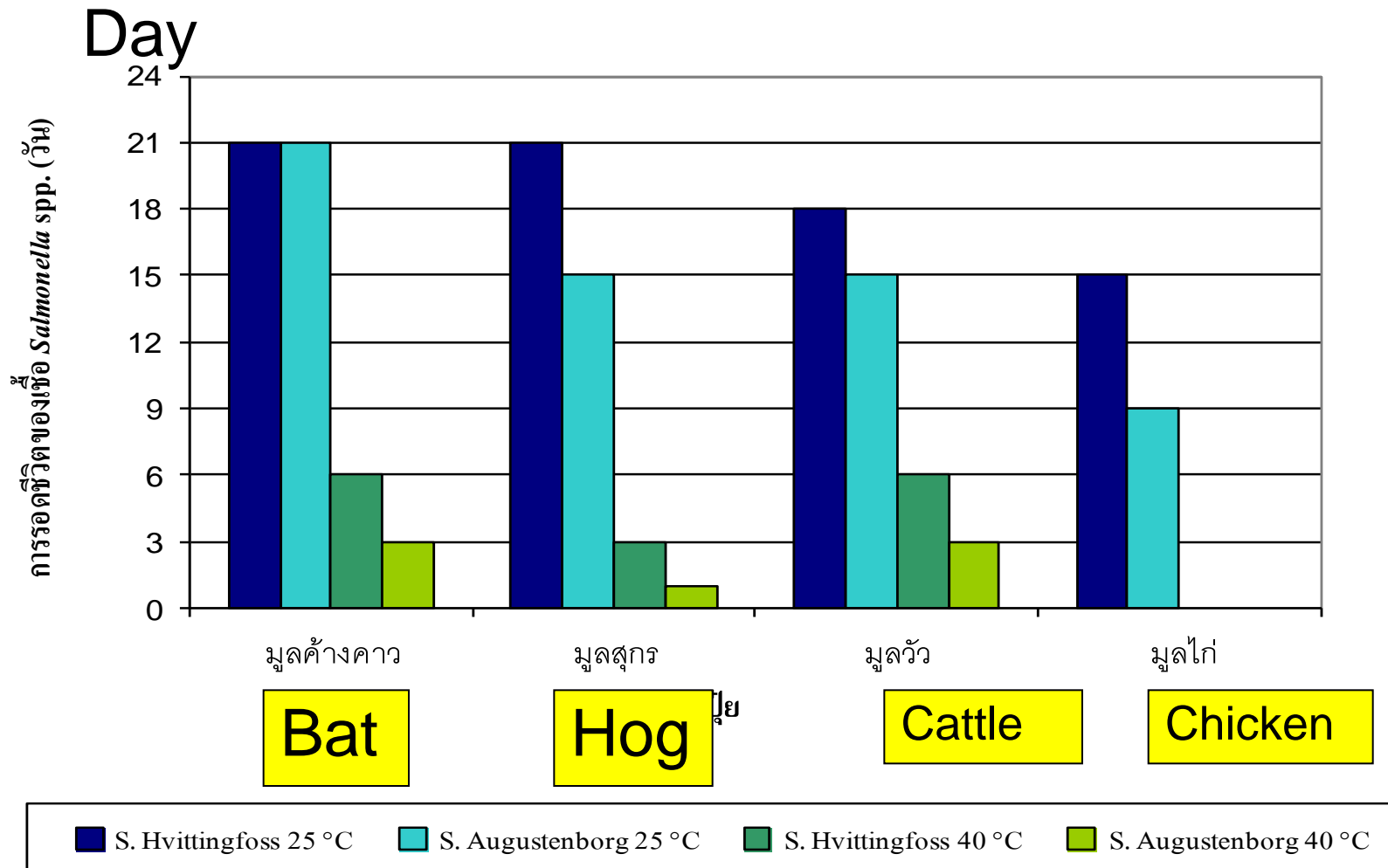


25±2°C



40±2°C





## Survival of *S. Augustenborg* and *S. Hvittingfoss* in dried animal fertilizers during Storage at 25C and 40C

วิภาวดี อันท้วม น้าทิพย์ ชันตยาภรณ์ และวราภา มหากาญจนกุล. 2553. ผลของอุณหภูมิเก็บรักษาต่อการรอดชีวิต ของ *Escherichia coli* และ *Salmonellae* ในปุ๋ยมูลสัตว์. ใน เรื่องเติมการประชุมทางวิชาการของมหาวิทยาลัยเกษตรศาสตร์ ครั้งที่ 48: สาขาอุตสาหกรรมเกษตรกรุงเทพ. มหาวิทยาลัยเกษตรศาสตร์. หน้า 401-40

❖ การประยุกต์ใช้สารออกซิไดส์ซึ่งในการล้างเพื่อลดสาร  
ตกค้างกลุ่มออร์กาโนฟอสเฟตในผักสด

❖ อัจฉรา และ วราภา, 2555



**Coriander**



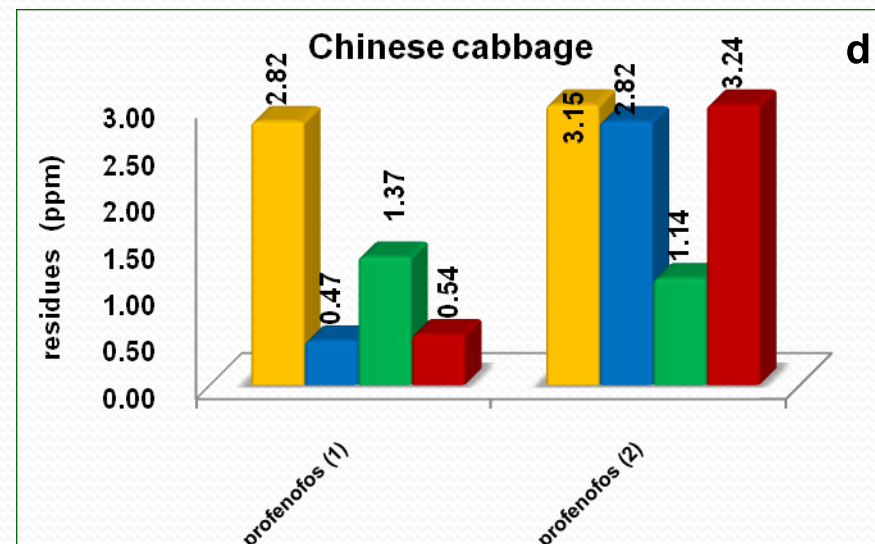
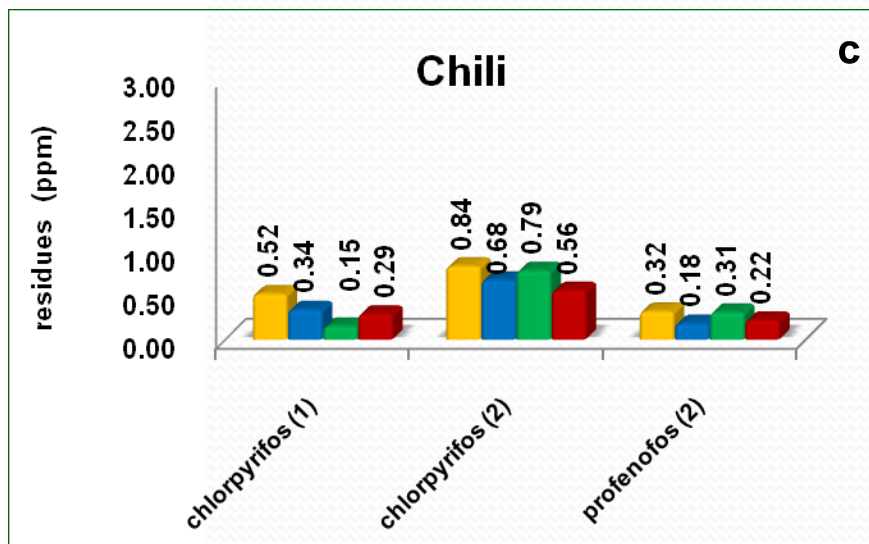
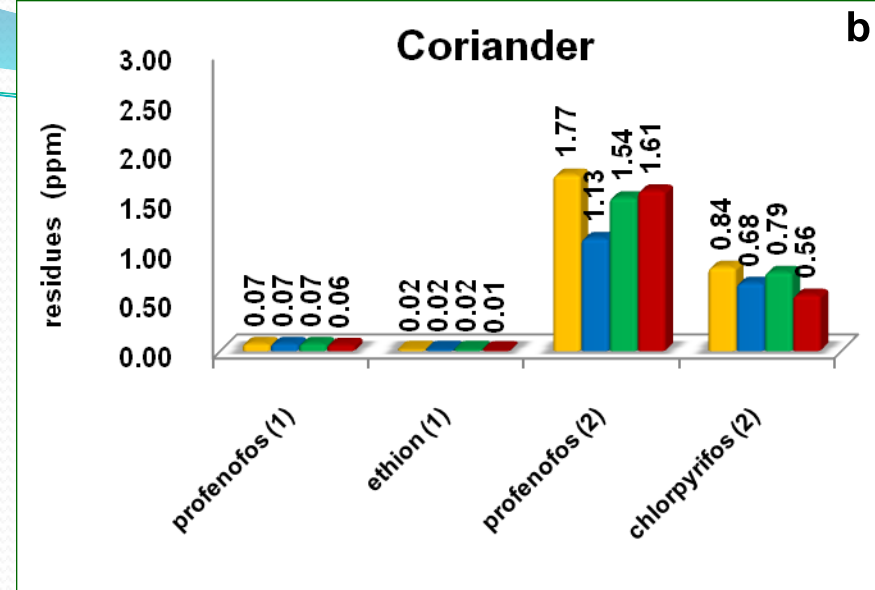
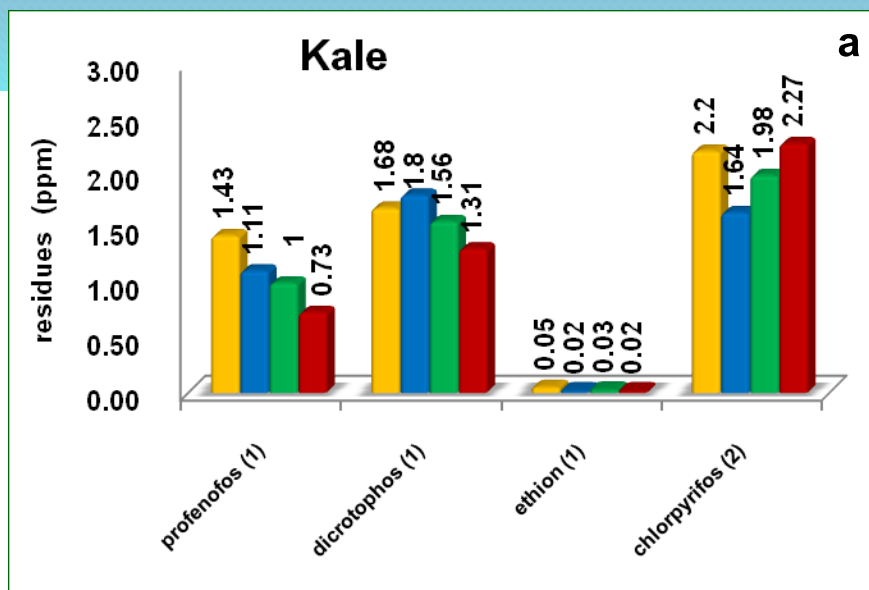
**Kale**



**Chinese cabbage**



**Chili**

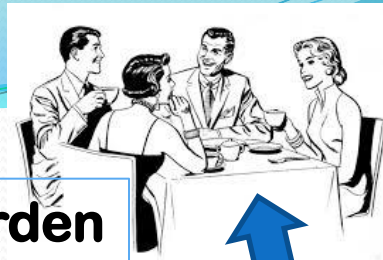


**Fig. Pesticides residue in different vegetables for export with oxidizing water; A: Kale, B: Coriander, C: Chili, and D: Chinese cabbage at 10 min ; (■) EO -water (■) ClO<sub>2</sub> (■) ozonated and (■) non washed**

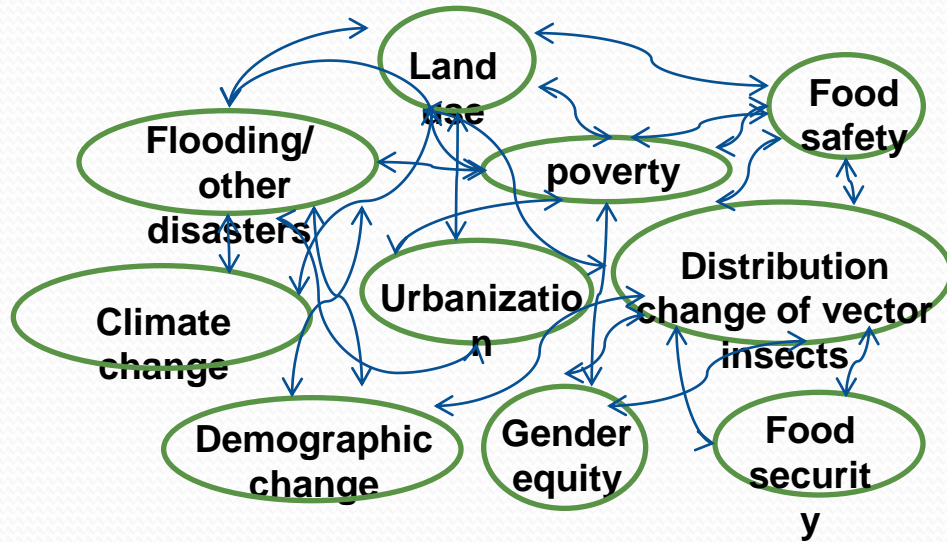
# **Has science changed (improved) the real world?**

- **Stopping global environmental change? No**
- **Support people to have better life? Yes and No**
- **Something has been lacking .....**
  - **Lack of collaboration with other disciplines within science e.g. social and natural sciences.**
  - **Science only cannot solve societal problems-need collaboration with stakeholders in the society and wisdom in the society.**

# Linking Food Safety Risk Assessment to Environmental Risk Assessment



Public health burden



Food Safety Objective



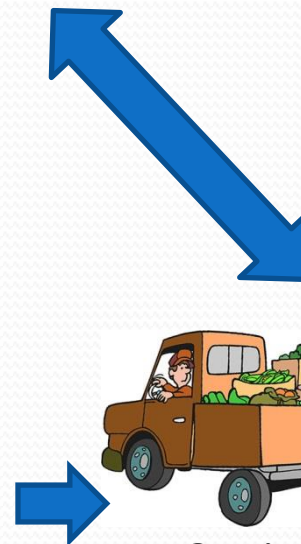
GHP



GMP



GHP  
HACCP



Code of  
practice



Modified from Dr. Fumiko Kasuga 7<sup>th</sup> Asian Conference on Food and Nutrition Safety, Penang Malaysia.Oct 11-13,2016



# Recommendations and Policy Propose

- **Interdisciplinarity**
- **Application of Good Practices**
- **Surveillance and monitoring**
- **Risk assessment**
- **Predictive modeling**
- **New technology**
- **Capacity building**
- **Risk communication**
- **Intra- and International engagement**



# Recommendations

- **Interdisciplinarity**

- **need to intensify the efforts to implement of food safety management system.**
- **need for input and coordinate between all sectors in the “farm to fork” food chain.**
- **need to promote interdisciplinary approaches to addressing challenges affecting food safety given the inter-relationships among environmental impacts, animal and plant health impacts and food hygiene.**

# Recommendations

- **Application of Good Practices**
  - Good hygiene practices
  - Good agricultural practices
  - Good animal husbandry practices
  - Good aquaculture practices
  - Good manufacturing practices
  - Good storage practices
  - etc.
  - Adjusting and applying the principle regarding changes in the occurrence and prevalence of food hazards as well as insects or other pest and their vectors.
  - Require applied research to better understanding the new ‘dynamics’ and evaluate different approaches for controlling the problem.
- **Developing a policy frameworks to help small and less developed businesses to overcome the constraints and encourage founding good practices programmes**



# Recommendations

- **Surveillance and monitoring, Risk assessment, Predictive modeling**
  - **Is essential for the early identification of emerging diseases and trends**
  - **the resource for planning and measuring the impact of control strategies.**
  - **Integrated monitoring and surveillance of human and animal disease, food contamination and environmental health is critical**



# Recommendations

- **Surveillance and monitoring, Risk assessment, Predictive modeling**
  - **Monitoring and surveillance programmes of country need to be reviewed and amended to address emerging hazards arising from global climate change.**
  - **The data generated from these programmes contributes significantly to predictive modeling and risk assessments.**
  - **Information should be shared both at national and international level.**

# Climate change

**Globalization**

**Consumer behavior**

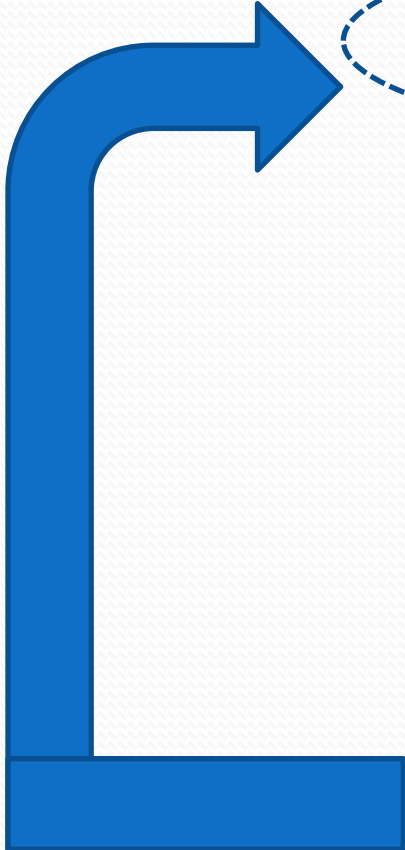
(micro) biological food safety of fresh produce  
Monitoring & test methodology  
Performance measurement of FSMS



**Simulation modelling**  
Logistic chain  
& Climate change scenarios  
& Packaging technology



**Adaptation scenarios**  
QA guidelines  
Risk based metrics



**Fig** Conceptual research model to develop new tools, methods and techniques to tackle the impact of climate change, globalization consumer trends on microbiological risk of fresh produce

## Recommendations

- **New technology and investment in scientific and technical capacities**
  - **A number of science and technologies play a major role to understand and deal with the food safety challenges**
  - **Influence the prioritisation of research investments**
  - **Investment in human resource development**
  - **Use of available competencies at national level by encouraging linkages between government services, universities, private sector association**
  - **Food safety capacity building by training and education**

## Recommendations

- **Risk communication**
  - **Education of consumers**
  - **Inform the risks to public health help to reduce both the use and trade of substandard food**
  - **Inform the emerging risks related to climate change and variability**
  - **Strengthened dialogue with the public**



# What food safety specialists can do..

- Keep our eyes widely open to identify new trends and affecting factors
- Work with other scientific disciplines and other partners .
- Interdisciplinary approach
- Co-creation of knowledge with stakeholders in the society:
  - Transdisciplinary approach, stakeholder engagement
    - Co-design: research planning (incl. theme, methods)
    - Co-production: research conduct
    - Co-delivery: application of the research products in the society

# References

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**Dr. Fumiko Kasuga , 13 Oct 2016. Environmental Change and Food Safety. Presentation slides at 4th Asia-Pacific International Food Safety Conference & 7th Asian Conference on Food and Nutrition Safety. October 11-13, 2016. Penang, Malaysia**