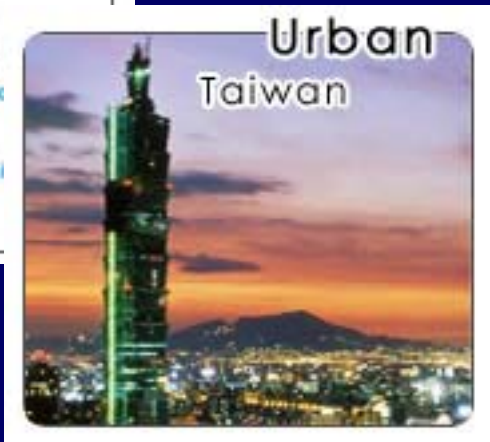


# Sustainable Development and Transportation: A Taiwan Perspective

Lawrence LAN

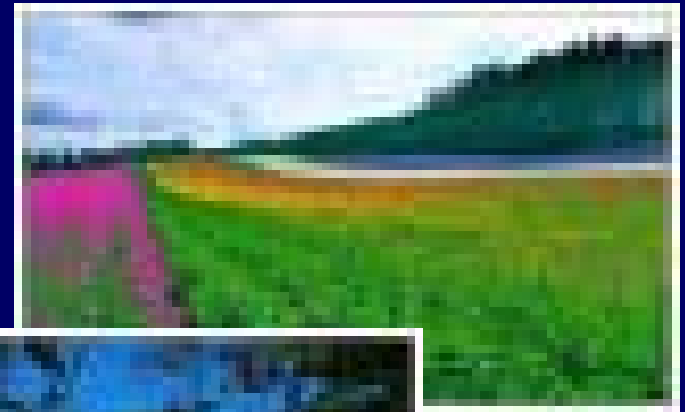
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# Outline

- Our Current Transportation
- Sustainable Development (SD)
- Sustainable Transportation (ST)
- Taiwan's Responses to SD
- Taiwan's Undertakings for ST
- Issues and Challenges

# A recent official press release – the Arctic Monitoring and Assessment Programme (AMAP)

<http://www.amap.no>

- **New scientific consensus:  
Arctic is warming rapidly; much  
larger changes are projected,  
affecting global climate**

# More ...from AMAP

- At least half the summer sea ice in the Arctic is projected to melt by the end of this century, along with a significant portion of the Greenland ice sheet, as the region is projected to warm an additional 4-7 °C by 2100.
- These changes will have major global impacts, such as contributing to global sea-level rise and intensifying global warming.
- Sea ice retreat will decrease habitats for polar bears and ice-living seals to an extent likely to threaten the survival of these species in the European Arctic.

# More ...from AMAP

- Over inland areas in the Scandinavian Arctic, average wintertime temperatures have increased in the last 50 years by about 2 °C.
- By 2090, model simulations project additional annual average warming of around 3 °C for Scandinavia.
- These temperature changes affect forest, tundra and biodiversity.

# More ...from AMAP

- Climate change impacts on forestry are expected to become more severe, with forest pest outbreaks causing the most extensive damage.
- As species move northward, alpine species in northern Norway, Sweden, Finland and Russia are most threatened because there is nowhere for them to go. The strip of tundra habitat between the forest and the ocean is particularly narrow and vulnerable to loss.

# More ...from AMAP

- Impacts of climate change and their implications for the availability of resources could lead to major changes in economic conditions and subsequent shifts in demographics, societal structure, and cultural traditions in the region.
- It is not only the extent of change but also the speed of change that is a major issue of concern.



# Our Current Transportation



# Took the Major Responsibility for Environmental Deterioration

- Transportation (international, intercity, urban and rural transport) systems in moving people and goods comprise infrastructures, vehicles, and maintenance and operation.
- Construction and maintenance of infrastructures, manufacturing and operation of vehicles, all rely heavily on fossil fuel resource and they all produce emissions, which have deteriorated the environments at local, regional, and global levels.

# Impacts of Emissions

- **Burning of fossil fuel** produces particulate matter (PM), ozone or volatile organic components (VOCs), carcinogenic toxics, carbon monoxide (CO), sulphur dioxide (SO<sub>2</sub>), and greenhouse gases,
  - **local impacts** due to high emission concentrations causing human illness and property loss...
  - **regional impacts** due to acidification and photochemical oxidants causing human illness and crops reduction...
  - **global impacts** due to indirect and direct greenhouse effect and stratospheric ozone depletion causing global warming and climate changes. Thus melt glaciers, expand ocean volume, overflow coastlines, foul freshwater supplies, disrupt land, collapse food supply chain...

# Other Environmental Impacts

- depletion of a non-renewable finite fossil resource
- decrease of land opportunities
- noise and vibration due to motor vehicle usage
- rapid reduction in natural habitats, number of species
- reduction of recyclable resources
- others, such as waste treatment

# Non-environmental Impacts

- huge financial burdens in maintaining and operating the infrastructures and transport service industries
- ubiquitous recurrent and non-recurrent congestions in the networks
- excessive injuries and fatalities due to vehicle accidents
- urban sprawl problems stimulated by motorized vehicle transport
- undesirable social disruption and poverty...

**Our transport  
systems are  
NOT  
SUSTAINABLE!**

# Sustainable Development

- “...development which meets present needs without compromising the ability of future generations to achieve their own needs and aspiration.” (World Commission on Environment and Development,1987)
- concern for **natural resources** and the **well being of human society** as well as the recognition of the **uncertainties** encompassed by the **time dimension** and **future resources, technologies and human values.**

# The 1992 Earth Summit

- Signed five documents
  - The Rio Environment and Development Declaration
  - The Agenda 21
  - The Framework Convention on Climate Change
  - The Convention of Biodiversity
  - The Forest Principle
- The United Nations Commission on Sustainable Development (UNCSD) was established to enforce, assist and monitor countries around the world to carry out sustainable development work.



# The 1997 Kyoto Convention

- The 1997 Kyoto Convention on Climate Change took further steps in achieving an international and legally binding agreement—called *The Kyoto Protocol*, which has more power to reduce greenhouse gases emissions worldwide.

# *The Kyoto Protocol*

- The Kyoto Protocol, entering into force on February 16, 2005, will control man-made emissions of the six gases: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), plus three fluorinated gases: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>).

# *The Kyoto Protocol*

- The Protocol has broken new ground by defining three innovative “flexibility mechanisms” to lower the overall costs of achieving its emissions targets. Two of the Protocol's flexible mechanisms, **Joint Implementation** and the **Clean Development Mechanism**, allow industrialized countries to invest in emissions-savings projects in third countries and use the resulting emission credits to help meet their Kyoto targets.

# Sustainable Transportation

- OECD (1996) defined **environmental sustainable transport (EST)** as “transportation that does not endanger public health or ecosystems and meets mobility needs consistent with
  - use of renewable resources at below their rates of regeneration
  - use of non-renewable resources at below the rates of development of renewable substitutes.”

# Sustainable Transport Indicators (OECD)

- **Transport-related emissions of NO<sub>x</sub>** have been reduced to the extent that the objectives for ambient nitrogen dioxide and for ozone level as well as for nitrogen deposition are achieved
- **Emissions of VOCs** have been reduced to the extent that excess ozone levels are avoided, and emissions of carcinogenic VOCs from all movement of all vehicles have been reduced to meet acceptable risk levels
- **Climate change** is being prevented by achieving per-capita CO<sub>2</sub> emissions from fossil fuel use for transportation consistent with the global protection goals for the atmosphere
- **Emissions of particulates** have been reduced to the extent that harmful ambient air levels are avoided
- **Land surface in urban areas** is used for movement, maintenance, and storage of motorized vehicles, including public transport vehicles such that the objectives for ecosystem protection are met
- **Noise caused by transportation** should not result in outdoor noise levels that present a health concern or serious nuisance.

# Making Transport More Sustainable

(OECD, 1996)

- significant reduction in car ownership and use
- shifts to more efficient vehicles
- reduced long-distance passenger and freight travel, particularly air travel
- increased non-motorized short-distance travel
- energy-efficient, electric powered, high-speed rail
- energy-efficient, less polluting shipping
- more accessible development patterns
- increased use of telecommunications to substitute for physical travel
- more efficient production to reduce long-distance freight transport.

# Responses to UN's Mandates

- The first North American response to the Agenda 21 was prepared by Canada. Its 1993 report on *The State of Canada's Environment* addresses several areas on the sustainability question (Redpath, 1993).
- *Sustainable Development: the UK Strategy* (Department of Environment, 1994) is another example; although it is not a transport report, transport did receive some attention in it.

# Responses to UN's Mandates

- In the United States, the White House issued *The Climate Change Action Plan* (Clinton and Gore, 1993), proposed a reduction in greenhouse gas emissions to 1990 level by the year 2000. Four federal programs were put in place:
  - Employees would be able to opt for the value of a parking place in dollars as income and arrange for their own transport (vans, buses, carpools) to work.
  - States would have to develop transportation system efficiency strategies ranging from market techniques to encourage people to drive less, parking charges, emissions-based fees, and transit subsidies.
  - Promotion of a greater use of telecommuting in order to decrease travel.
  - Federal DOT was to establish a system for labeling the fuel economy of different tires.



# Responses to UN's Mandates

- The President's Council on Sustainable Development (1966) further issued a statement, entitled *Sustainable America*, in which four sets of steps that would make transportation more sustainable were identified:
  - Improve community design to contain sprawl better, expand transit options, and make efficient use of land within a community. Locate homes for people of all incomes, places of work, schools, businesses, shops and transit in close proximity and in harmony with civic spaces.
  - Shift tax policies and reform subsidies to significantly improve economic and environmental performance and equity in the transportation sector.
  - Make greater use of market incentives, in addition to changes in tax and subsidy policies, to achieve environmental objectives.
  - Accelerate technology developments and encourage public-private collaboration to move industrial sectors closer to economic, environmental and equity goals.

# Responses to UN's Mandates

- As the EEA reported in July, 2004, the EU-15 has so far cut its overall emissions of the six greenhouse gases controlled under the Kyoto Protocol to 2.9 % below 1990 levels. Emissions decreased from most sectors, including energy supply, industry, agriculture and waste management. **However, emissions from transport increased by nearly 22 % in the same period.**
- Each of the EU-15 countries also has an agreed, legally binding target for limiting or cutting its own emissions to ensure the overall 8% reduction is met. At present Denmark, Italy, Portugal and Spain are on course for above-target emissions, some by a wide margin, even with use of the Kyoto mechanisms and additional measures planned. Germany is in danger of slightly exceeding its emission limit on the basis of existing policies and measures.

# Responses to UN's Mandates

- Latest projections compiled by the EEA show that the EU-15 should cut their total emissions to 7.7% below 1990 levels by 2010 on the basis of existing domestic policies and measures already being implemented and additional policies and measures currently planned.
- Plans by six EU-15 Member States to use credits from emissions-saving projects in third countries through the Kyoto Protocol's "flexible mechanisms" would contribute a further reduction of around 1.1%, taking the total to 8.8%. This is more than the 8% decrease from 1990 levels that the EU-15 has committed itself to achieving by 2008-2012 under the Protocol to combat climate change.

# Taiwan's Responses to SD

## *-The Agenda 21 of Taiwan-*

- In August 1997, the Executive Yuan set up the National Council for Sustainable Development (NCSD)
- In May 2000, the NCSD drafted *The Agenda 21 of Taiwan: the Guidelines for the National Sustainable Development Strategy*
- In December 2002, *the Environmental Basic Law* was promulgated. Article 29 of this law states that “**the Executive Yuan should establish the National Council for Sustainable Development to respond to the relevant policy making and decisions of sustainable development in Taiwan, and pass to the relevant agencies for execution.**”

# Ten Basic Principles

*(The Agenda 21 of Taiwan)*

- Generation fairness
- Environmental loading
- Balanced consideration
- Prior precaution
- Social justice
- Public participation
- Cost internalization
- Science and technology emphasis
- System integration
- Global participation

# Nine Integrated Strategies

## *(The Agenda 21 of Taiwan)*

- Creation of good environmental quality
- Creation of eco-balanced urban environment
- Promotion of social welfare policies
- Adjustment of lifestyle and personal behavior modes
- Promotion of risk management and proactive planning for economic development
- Adjustment of energy policies and industrial structure and building a cleaner production mechanism
- Promotion of educational reform
- Promotion of public policy participation
- Adjustment of organizational structure and proceeding with governmental reconstruction

# Twenty-two Action Guidelines

## *(The Agenda 21 of Taiwan)*

- Sustainable environment, including atmosphere, water resources, terrestrial resources, marine resources, biodiversity, environmental management
- Sustainable society, including population and health, residential environment, social welfare, preservation of cultural heritage, disaster prevention and response
- Sustainable economy, including economic development, industry development, transportation development, energy strategy, resource recovery
- Development motivation, including educational development, science and technology development, informationized society
- Promotion mechanisms, including public participation, governmental restructure, and international cooperation

# Forty-two Sustainable Development Indicators

*(The Agenda 21 of Taiwan)*

- The NCSD has been extremely proactive in promoting efforts towards the development of a set of national sustainable development indicators (SDIs) and in putting into place the relevant mechanisms for recording, measuring, announcing and reviewing these indicators.
- Initially, 112 SDIs were proposed; finally only 42 SDIs were selected, including six core dimensions (ecological resources, environmental quality, social pressure, economic pressure, institutional response, and urban unsustainable development) and are divided into two categories (island Taiwan indicators and urban Taiwan indicators).



# Comments

## *(The Agenda 21 of Taiwan)*

- Educate people to arouse public awareness of the importance of environmental protection, social safety, and open economy
- Strengthen science and technology development for clean and substitute energy with low or no pollutants in both production and consumption sectors
- Provide stronger government interventions (prohibition, regulation, subsidy, taxation) and market forces (pricing, quantity, quality) to enhance energy efficiency and to reduce emissions and wastes

# Taiwan's Undertakings for ST

## - *Transportation Policy White Books* -

- Over the recent three decades, Taiwan has enjoyed the blossom of economic growth with annual growth of gross domestic product (GDP) averaged about 8%. The per capita GDP was US \$12,588 in 2002, rising from the 20th world position in 1990 to the 17th (DGBAS, 2002). During the same period, the average economic growth rate was 6.4%, which was much higher than the world's average (2.7%).
- In 2003, its population has reached 22.61 millions and the number of motor vehicles was 18.50 millions -- two-thirds of which were motorcycles (12.367 millions) and the other one-third were motor vehicles (6.134 millions). In terms of private vehicle ownership, every 4.37 persons owned a passenger car that year and every 1.83 persons possessed a motorcycle.

# Unsustainable Transport Problems

- Due to the long and narrow geography (394 km long and 144 km width) with barrier of the central mountains, the major intercity transportation systems of Taiwan are north-south direction mainly connecting three metropolitan areas and other urbanized areas. Private vehicles have made the majority of daily personal trips. According to the 1995 national household interviews and traffic surveys, of the 34.66-million short-distance (within 50 kilometers) daily trips, 81% were made by private vehicles and only 19% by public transportation. Of the 895-thousand long-distance (beyond 50 kilometers) daily trips, 62% were made by private vehicles and 38% by public transportation (IOT, 2002).
- The heavy dependence on private transport in Taiwan has caused serious impacts to the environmental, economic and societal systems, thus had led this island country towards unsustainable development.

# Responses to UN's Mandates (Taiwan's Proclaims for ST)

- **Environmental sustainability:** to enhance the efficiency of transportation energy usage and to lower the air, noise, water pollution and greenhouse gas emissions by introducing low pollution and high energy efficiency transportation systems as well as by lowering the environmental impacts from transport activities.
- **Economic sustainability:** to promote the growth of economic development and to enhance the operating efficiency of transport services by stimulating more private participation in transport infrastructures, more liberalization and privatization in transport service industries, and expediting the operational processes in the inter-modal transport systems.
- **Social sustainability:** to ameliorate overall transportation quality as well as to consider the social equity by providing safe, healthy, and comfortable transportation environment while meeting the basic needs of transport for all people.

# *The White Books*

(MOTC, 1995, 2002)

- In its first *Transportation Policy White Book*, released in 1995, Taiwan has proclaimed the pursuit of sustainable development by factoring the environmental, economic and societal considerations into the transport policy decision-makings. Development of public transport with priority was viewed as the most prominent policy to break (or even reverse) the direction of previous public-private transport vicious circle.
- “Carrot and stick” policy planning philosophy was clearly documented in the 1995 White Book. More explicit policies and strategies for the development of public transport were clearly outlined in the 2002 revised White Book.

# Public Transportation Development Act (PTDA, 2002)

- subsidize the capital investment and operation deficit to those routes serving in remote districts
- requires the regulatory agencies to conduct periodical assessment on the operation of public transportation
- pushes for constructing more bus exclusive lanes and public transit terminals and for integrating the systems
- permits carriers to charge full fare, discount for special passengers subsidized by governments

# Important Deployments for ST

- Enhancement of Mass Transport Program (1996-2001)
- ITS applications
- Upgrading public transportation schemes (2002-2008)
- Providing more guideway transport

# Enhancement of Mass Transport Program

- Tax/fee/toll exemption
- Direct subsidy
- Deregulation -- open freeway market
- Periodic assessment of transit service quality



# ITS Applications

- electronic ticketing (Easycards)
- real-time bus information system
- spoken LED units
- digital tachometers
- electronic toll collection (ETC)
- satellite taxi and dial-a-ride paratransit

# Seven Schemes for Upgrading Public Transport

(National Development Plan, 2002)

- provide the local governments with budgets to plan the service integration among different public transit systems,
- provide the budget to build public transit terminals
- provide the local governments with financial assistance to construct bus exclusive lanes
- provide the budget for implementing bus service appraisal every two years
- subsidize the bus carriers to invest in purchasing new buses
- subsidize the bus carriers to create electronic ticketing systems
- continuously subsidize the operating deficits of bus routes serving in the remote areas

# Providing More Guideway Transport

- Taipei metro
- Taiwan High Speed Rail
- Kaohsiung metro
- CKS Airport—Taipei rapid transit
- Light rails, people movers, BRT, etc.

# Comments

## (Taiwan's Sustainable Transportation)

- Inadequate “sticks” to cars and motorcycles ownership and usage
- Insufficient “carrots” to public transport
- Impacts of high speed rail to domestic air, freeway bus and Taiwan Railway Administration (TRA)
- Financial unsustainability of TRA
- Indirect transport between Taiwan and Mainland

# Issues and Challenges

- Estimation of life-cycle costs of any of transport undertakings to future generations, including environmental, societal, and economic systems:
  - Corrections for externalities
  - Externalities costing
  - Vagueness of sustainability
  - A vision of the future
  - Roles of civil engineering

# Corrections for Externalities

- Many of the sustainability indicators do not have market values.
- To correct the market failures, Pigouvian tax needs to be imposed with marginal social cost (Pigou, 1938).
- This concept is simple but the estimation of marginal social cost is complicated.

# Externality Costing

- Hedonic-pricing method
- Damage-function method (or dose response approach)
- Both are for short-term estimation
- Intergenerational costing or lifecycle costing for transport externalities has yet been well addressed

# Vagueness of Sustainability

- **Duration of impacts** (how many generations need to be considered?)
- **Indicators representing the impacts** (e.g., human illness and death, ecosystem damage, reduction in biodiversities, climate change, stratospheric ozone depletion, ground-level ozone formation, emissions of particulates, noise and vibration, land use changes, resource use, waste disposal, water pollutions, hydrological impacts, etc.)
- **Considering the vagueness of sustainability definition, the lifecycle full-costs pricing would become even more difficult.**



# Fuzzy Mathematical Programming

## (FMP) (Inuiguchi and Ramik, 2000)

- **flexible programming:** deals with vague objective or right-hand-side constraints
- **possibilistic programming:** associates with ambiguous parameters
- **robust programming:** relates to vagueness and ambiguity for both

# An illustration of FMP

$$\text{Max } Z = \sum_{t=0}^T \frac{x_t}{(1+r)^t}$$

$$s.t. \quad \alpha_t \geq a_t, t = 0, \dots, T$$

$$\beta_t \geq b_t, t = 0, \dots, T$$

$$x_t \geq 0, t = 0, \dots, T$$

# Problems of FMP

- Determination of cortexes or spreads of fuzzy numbers could be too subjective
- Our current value systems could be too subjective, too
- These are perhaps not agreed by our future generations

# A Vision of the Future

(Mitchell, 1995)

- spatial or anti-spatial
- corporeal or in-corporeal
- focused or fragmented
- contiguous or connected
- synchronous or asynchronous
- narrowband or broadband
- nervous system or bodynet
- hands or telemanipulators
- brains or artificial intelligence
- façade or interface
- bookstores or bitstores
- work or network, at home or @home
- face-to-face or interface
- on the spot or on the net
- street networks or worldwide web
- neighborhoods or MUDs (multi-user dungeons)
- public space or public access
- moving materials or processing bits
- territory or topology

# Roles of Civil Engineering

- “土木” is a sustainable development engineering. The first character “土” means earth, environment, and resources. The second character “木” means forest, ecology, and hazard mitigation.
- The core duty of civil engineers is to construct and maintain infrastructures to create a safe, healthy, comfortable, and sustainable living environment and to build a pleasant world in harmonious with the nature.

# Concluding Remarks

- In the construction and maintenance of transportation infrastructures, we need to **advance the science and technology of “土木” and related professions so as to promote the preservation of the precious environment and prevention of the natural disasters**

# Concluding Remarks

- In the design and manufacturing of vehicles and facilities, we need to **enhance the safety, comfort, and rapidity of vehicles or equipment and endeavor to the energy saving and emissions reduction**

# Concluding Remarks

- In the operation and maintenance of the transportation systems, we need to **reduce new constructions by extending the service life of existent infrastructures; to reduce the intensity and distance of transportation by reshaping the land-use patterns and better utilizing the substitutes**



# Concluding Remarks (OECD)

- In sum, the overall transport undertakings must not endanger the public health or ecosystems while meeting the mobility needs. They must comply with two basic principles:
  - use of renewable resources at below their rates of regeneration
  - use of non-renewable resources at below the rates of development of renewable substitutes

**Let us work tightly together,  
let our future generations  
work together...towards  
greater achievements of  
sustainable earth!**

**...until forever...**

# Thank You Very Much



# Discussions

