

ISSN 1913-9063

JOURNAL OF SUSTAINABLE DEVELOPMENT

**Vol. 2, No. 1
March 2009**



Canadian Center of Science and Education

Editorial Board

Balasubramanian Natesan Anna University-Chennai, India

C. Srinivasakannan Monash University, Sunway Campus, Malaysia

Fransiscus Xaverius Suryadi UNESCO-IHE, the Netherlands

Hamimah Adnan Universiti Teknologi Mara, Malaysia

Kebreab Ghebremichael UNESCO-IHE-Institute for water education, the Netherlands

M. Asif Glasgow Caledonian University, UK

Md. Saidul Islam The College of William and Mary, USA

Rajamohan Ganesan Curtin University of Technology, Sarawak Campus, Malaysia

Susan Sun Canadian Center of Science and Education, Canada

Syahrul Nizam Kamaruzzaman University of Malaya, Malaysia

Thanh Nguyen Monash University, Australia



Contents

Possible Us-Iran Military Conflict and Its Implications upon Global Sustainable Development	3
<i>Muhammad Asif & Muhammad Tayyeb Khan</i>	
The Analysis and Counter-Measures Discussion about Information Asymmetry in the Operation and Management patterns of Organic Agriculture -----Based on Comparison between Zhongliangmeiyu Ltd in Heilongjiang Province and Company A in F City, Shandong Province and an Analysis Used SWOT Approach	10
<i>Xinmin Zhang, Yongfu Chen, Chuncheng Liu & Jialin Xin</i>	
The Relationship between Poverty, Conflict and Development	15
<i>Brian-Vincent IKEJIAKU</i>	
Harmonious Sports: the Ideal Pattern of the Sustainable Development for the Competitive Sports	29
<i>Te Bu</i>	
Carbon Dioxide Emission Savings Potential of Household Water Use Reduction in the UK	36
<i>M.J. Hackett & N.F. Gray</i>	
Study on the Leisure Sport and the Sustainable Development of People	44
<i>Houzhong Jin</i>	
Geo-information Science for Sustainable Development of Mount Stong F.R., Kelantan, Malaysia	51
<i>Kamaruzaman Jusoff & A.K Skidmore</i>	
Study on the Case Teaching Method and the Sustainable Development Education for the Inner Mongol Colleges	65
<i>Qingguo Meng</i>	
Preparation and Characterization of Bio Fuel from Industrial Waste	71
<i>M.N Abinayah Shree, K. Iyappan, N. Balasubramaniam & C Srinivasakannan</i>	
Study on the Implementation of Green Supply Chain Management in Textile Enterprises	75
<i>Fengfei Zhou</i>	
Malaysian Agricultural: Conventional and Extended Thoughts	80
<i>Pek Chuen-Khee</i>	
The 0-1 Programming Solution for the Problem of Resource Allocation	87
<i>Guoliang Luo & Xingang Zhao</i>	
Management Strategies for a Seawater Intruded Aquifer System	94
<i>Madhavi Ganesan & S.Thayumanavan</i>	
Classification and Salt-tolerance of Actinomycetes in the Qinghai Lake Water and Lakeside Saline Soil	107
<i>Yan Cai, Quanhong Xue, Zhanquan Chen & Rong Zhang</i>	
Personnel Characteristics of Maintenance Practice: A Case of High-Rise Office Buildings in Malaysia	111
<i>Emma Marinie Ahmad Zawawi & Syahrul Nizam Kamaruzzaman</i>	
Current Situation of Energy Consumption in Guangzhou Railway Station and Analysis on the Potential of Energy Conservation	117
<i>Kai Fu & Zhihui Deng</i>	
Vascular Epiphytes Diversity at Pusat Sejadi, Kawang Forest Reserve, Sabah Malaysia	121
<i>Andy Russel Mojiol, Anna Merlyn Aloysius Jitimu, Audrey Adella, Gloria Muring Ganang & Narbet Nasly</i>	



Contents

Nontraditional Diplomacy---Chinese Ecological Diplomacy	128
<i>Jingwei Liu & Tianyang Sun</i>	
Long Term Shoreline Oscillation and Changes of Cauvery Delta Coastline Inferred from Satellite Imageries	132
<i>R. Sathyanarayan Sridhar, K. Elangovan & P. K. Suresh</i>	
Research on Evaluation Index System of Enterprise Innovation Culture Based on Sustainable Development	143
<i>Chunyan Shao</i>	
International Migration, Remittances and Development	147
<i>Hasan Mahmud, Md. Abdus Sabur & Sharmin Tamanna</i>	
Study on the Ban on Free Plastic Bags in China	156
<i>Xiufeng Xing</i>	
Challenges of Sustainable Physical Planning and Development in Metropolitan Lagos	159
<i>'Leke Oduwaye</i>	
Study on the Law Regulations about Circular Regions	172
<i>Boyu Zhu & Muwen He</i>	
Timor Mountain Gum Improvement Program in Eastern Thailand	176
<i>Mandy Maid & Suree Bhumibhamon</i>	
Multiple Time Scales Analysis of Precipitation in Hotan, China	182
<i>Jiqing Lv, Bing Shen & Shuhong Mo</i>	
Post Occupancy Evaluation towards Indoor Environment Improvement in Office Buildings	186
<i>Natasha Khalil & Husrul Nizam Husin</i>	
Enterprise Social Responsibility and Enterprise Sustainable Development	192
<i>Huiyuan Mao & Yunfeng Ai</i>	
Biofilm and Multimedia Filtration for Rainwater Treatment	196
<i>Rasima Abdul Rasid, Rakmi Abdul Rahman & Rasina Abdul Rasid</i>	
An Introduction of Building Green Schools	200
<i>Juan Zhang, Zhirong Zhang & Yu Zheng</i>	
Study on the Application of the Double-membrane Technology in Dealing with Circulating Cooling Blow-off Water to Prepare the Boiler Feedwater	204
<i>Lei Qu, Liang Wang, Lin Shao & Peng Qi</i>	
Recycling Economy and Sustainable Development	209
<i>Hua Liu</i>	



Possible Us-Iran Military Conflict and Its Implications upon Global Sustainable Development

Muhammad Asif (Corresponding Author)

School of the Built and Natural Environment

Glasgow Caledonian University

Cowcaddens Road, Glasgow, G4 0BA, UK

Tel: 44-141-331-8721 E-mail: Muhammad.Asif@gcal.ac.uk

Muhammad Tayyeb Khan

School of Government and International Affairs

Durham University

The Al-Qasimi Building, Elvet Hill Road Durham DH1 3TU, UK

Tel: 44-191-334-5656 E-mail: m.t.khan@durham.ac.uk

Abstract

Energy is one of the most basic of human needs. The accomplishments of civilization have largely been achieved through the increasingly efficient and extensive harnessing of various forms of energy to extend human capabilities and ingenuity. Providing adequate and affordable energy is essential for eradicating poverty, improving human welfare, and raising living standards worldwide. The Persian Gulf is regarded as the energy headquarters of the world since the region holds over 65% of the global oil reserves and contributes to nearly 28% of the world oil supplies. Despite its crucial role in propelling the economic growth of the world over the last sixty years, the region has traditionally experienced a volatile geo-strategic environment. The article focuses on the escalating tension between the United States and Iran. It highlights the broader socio-economical implications of a possible military conflict between the two countries.

Keywords: Persian Gulf, Sustainable development, Fossil fuel, Energy security

1. Introduction

With the growing world population and people's innate aspirations for improved life, the paramount global challenge in the new century would be sustaining economic growth within the constraints of the planet's limited natural resources. The population growth and the inevitable need to expand economic output would place enormous demands on the stock of natural and environmental resources. Poor and inadequate access to secure and affordable energy is one of the major concerns for sustainable development. There appears to be a global consensus that provision of secure, affordable and socially acceptable energy services is a prerequisite for eradicating poverty in order to achieve the Millennium Development Goals (MDGs), as also concluded at the Earth Summit 2002. More than 1.6 billion people – nearly one quarter of the world's population - have no access to electricity. If the MDGs target is to be reached, 500 million more people would need to be electrified by 2015.

Since the beginning of the twentieth century oil has been a crucial factor in the economic growth of the world. Its importance is more pronounced with the spread of transportation. The global oil reserves are extremely localized. The fact - less than 15% of the countries in the world are self sufficient in their oil needs - results in two groups: net importers and net exporters of oil. The interdependence between these groups plays a significant role in shaping global economic and political developments. Persian Gulf is the most prominent energy centre of the world as it contributes to 28% of the current global oil requirements while holding 65% of the total oil reserves in the world as shown in Fig. 1. The Persian Gulf region also has a long history of geo-strategic conflicts. Four out of the five richest countries in the world in terms of oil reserves: Saudi Arabia, Iran, Iraq and Kuwait, jointly holding over 55% of global oil reserves, come from this region and have directly experienced warfare within last three decades. Another major crisis appears to

be approaching the region as senior US officials are repeatedly issuing warnings over use of force against Iran for a number of reasons, particularly if the country continues its nuclear program.

2. Energy and Sustainable Development

Energy is the backbone of human activities. Provision of sufficient, secure and affordable energy is crucial for the sustainability of modern societies. The accomplishments of civilization have largely been achieved through the increasingly efficient and extensive harnessing of various forms of energy to extend human capabilities and ingenuity. Providing adequate and affordable energy is essential for eradicating poverty, improving human welfare, and raising living standards worldwide. Availability of energy in any country has a strong relationship with its economic and social stability. The per capita energy consumption is an index used to measure the prosperity of any society as also indicated in Fig. 2 (Christian Kornevall, 2004). Easy access to adequate energy is crucial for continued human development. Throughout the course of history, with the evolution of civilizations, the human demand for energy has continuously risen. Of present, key factors driving the growth in energy demand include increasing human population, modernization and urbanization (Muneer, T., & Asif, M. 2007).

Statistics suggest that during the 20th century urban population in the world experienced a rapid growth as shown in Table 1 (Charles Hirschman, 2008). By 2007, world population grew to over 6.6 billion. World population in 2008, for the first time in history, nearly half of global population will be living in urban areas. By 2030, out of the total estimated population of around 8 billion, 5 billion would be living in urban areas. Figures also indicate that most of the urbanization is set to take place in the lesser developed part of the world - by the same time, the towns and cities of the developing world will make up 81 per cent of urban population.

The growth-trends of population and energy demand are complimenting those of the urbanization. According to the United Nations estimates, world population, 6.5 billion in 2005, is to grow to 9.1 billion by 2050. Most of the population growth will take place mostly in the developing world – Asia and Africa. The International Energy Outlook projects strong growth for worldwide energy demand up to 2025. In the IEO2005 mid-term outlook, the emerging economies account for nearly two-thirds of the increase in world energy use, surpassing energy use in the mature market economies for the first time in 2020. In 2025, energy demand in the emerging economies is expected to exceed that of the mature market economies by 9%. Much of the growth in energy demand among the emerging economies is expected to occur in emerging Asia, which includes China and India; demand in this region is projected to more than double over the forecast period. Primary energy consumption in the emerging economies as a whole is projected to grow at an average annual rate of 3.2% up to 2025. In contrast, in the mature market economies—where energy consumption patterns are well established—energy use is expected to grow at a much slower average rate of 1.1% per year over the same period. In the transitional economies of Eastern Europe and the former Soviet Union, growth in energy demand is projected to average 1.6% per year. The total world consumption of marketed energy is expected to expand by 57% over the 2002–2025 time period (Muneer, T., & Asif, M. 2007).

With the growing world population and people's innate aspirations for improved life, a central and collective global issue in the new century will be sustaining economic growth within the constraints of our planet's limited natural resources while at the same time preserving our environment, thus ensuring sustainable development.

3. Global Energy Challenges

Different forms of energy that are being employed worldwide to meet human energy requirements can be broadly classified into three types: fossil fuel, nuclear power and renewables. The world energy market is predominantly led by fossil fuels that contribute to nearly 80% of the total supplies. Renewable energy and nuclear power are, respectively meeting 13.5% and 6.5% of the total energy needs (IEA, 2007). The present global energy scenario faces four major challenges: depletion of fossil fuel reserves, climate change, energy security concerns and rising fuel prices, as discussed under.

3.1 Depleting fossil fuel reserves

World ultimate conventional oil reserves are estimated at 2000 billion barrels. This is the amount of production that would have been produced when production eventually ceases. According to the Organization of the Petroleum Exporting Countries (OPEC) February 2008 report, the global daily consumption of oil is to rise from 85.8 million barrels in 2007 to 87 million barrels in 2008 (OPEC, 2008). Different countries are at different stages of their reserve depletion curves. Some, such as the United States, are past their midpoint and are in terminal decline, where as others are close to midpoint such as UK and Norway. However, the five major Gulf producers—Saudi Arabia, Iraq, Iran, Kuwait and United Arab Emirates - are at an early stage of depletion and can exert a swing role, making up the difference between world demand and what others can supply. The expert consensus is that the world's midpoint of reserve depletion will be reached when 1000 billion barrels of oil have been produced—that is to say, half the ultimate reserves of 2000 billion barrels. It is estimated that around 1000 billion barrels have already been consumed and 1000 billion barrels of proven oil reserves are left in the world (Asif, M., Currie, J., & Muneer, T. 2007).

3.2 Climate change

The global climate has changed dramatically over the last century. Climatic changes driven by human activities, in particular the production of greenhouse gas emissions (GHG), directly impact the environment. Energy sector has a key role in this regard since energy during its production, distribution and consumption is responsible for producing environmentally harmful substances. During energy use, varied stresses are created on the natural environment, some of which have global implications like the global warming while others cause local impacts such as their effect on human health and ecology. Coal exploration and mining, for example, causes land degradation through subsidence and mine fires. The impact of mining on forest areas is of particular concern. Similarly, with onshore oil and gas production drilling waste fluids, drilling waste solids, produced water and volatile organics exhibit the potential to contaminate surrounding water bodies. For the last 150 years, industry has been releasing CO₂ into the atmosphere at a rate of millions of times greater than the rate at which it was originally accumulated underground. Deforestation alone has been responsible for around 20 Gt of carbon since 1800 (Muneer, T., Asif, M., & Munawwar, S. 2004). The mean global surface temperature has increased by 0.4–0.8 °C in the last century above the baseline of 14 °C. If nothing is done, global temperatures could rise by up to 6 °C by 2100 (R. Sims. 2004). If GHG emissions are unabated, natural catastrophes inflicting damage to ecology of the planet and its inhabitants are expected to occur more frequently and intensely in future. Physical infrastructure will be damaged, particularly by sea-level rise and by extreme weather events. Water resources will be affected as precipitation and evaporation patterns change around the world. The way to repair the already inflicted damages of global warming and a rather safe escape from the anticipated threats is an immediate change in the overall energy sector. There needs to be a global drive on two fundamental fronts: firstly to conserve energy and to increase the efficiency of existing energy resources, secondly to switch the energy systems from existing energy resources to renewables that are clean and environment friendly.

3.3 Energy security

Energy security is a key addition in the catalogue of the challenges facing the global energy scenario. In the energy-dependant modern age, prosperity in any society is subject to an adequate and consistent provision of energy - the socio-economics of all countries greatly depend on secure supplies of energy. Energy security means consistent availability of sufficient energy in various forms at affordable prices. These conditions must prevail over the long term if energy is to contribute to sustainable development. Fossil fuels in general and oil in particular (contributing 36% of the global energy requirements) is extremely localized in nature. Attention to energy security is critical because of the uneven distribution of the fossil fuel resources on which most countries currently rely. The Persian Gulf region, housing nearly over 65% of the world oil reserves, as a whole has quite a volatile geopolitical situation as it has seen a number of conflicts over past few decades. The oil factor cannot be ruled out in some of the major conflicts in the area. There are serious reservations regarding security of oil; production and supply channels of some of the Middle-Eastern countries like Iraq that is the second largest oil-producing country in the world, are regarded as the legitimate targets of radical elements because of various internal and external conflicts.

3.4 Surging oil prices

In recent years, the volatile global oil market has been experiencing consistently surging oil prices (as shown in Fig. 3) affecting the socio-economic conditions across the world. Crude oil price for a barrel, standing at US\$66.4 on average in 2007 has grown to nearly US\$140 in June 2008, recording an over 90% increment within last few months. There are a number of factors considered to be responsible for the surging price trend such as growing demand for oil especially in emerging economies such as China and India, receding excess production capacity and weak position of US\$. Political unrest, military conflicts and extreme weather events are also amongst the factors that have traditionally played their role in causing rapid rise in global oil prices. The track record of oil prices indicate that several such issues like Yom Kippur War (1973), Iranian Revolution (1979), Iran/Iraq War (1980), First Gulf War (1991), unrest in Venezuela (2002) and Second Gulf War (2003) have all contributed to a rapid increment in crude oil price. The vulnerability of oil market has grown to such an extent that incidents of much smaller scale are capable of adversely affecting it. For example, in August 2005, the oil prices were noticed to make an immediate jump from US\$57 to more than US\$65 at the news of the death of King Fahad-the late king of Saudi Arabia [11]. Similarly, on 27 March 2008, crude oil prices jumped from \$102/barrel to \$108/barrel, just because a pipe line was sabotaged in Basra (Iraq).

4. Possible US-Iran Military Conflict and Energy Prices

The traditionally volatile US-Iran relationships are heading towards an all time low. Over the last few years, the US has been expressing reservations over Iran's nuclear program and alleged support for extremist groups in the region. The state of the Union address of the President Bush on 29 January 2009, declaring Iran, Iraq and North Korea as an "axis of evil" explain the sourness of the US-Iran relationship. Referring to the three countries, Bush said "States like these, and their terrorist allies, constitute an axis of evil, arming to threaten the peace of the world. By seeking weapons of mass destruction, these regimes pose a grave and growing danger". The underlying tensions between the two countries have heightened since the US invasion of Iraq in 2003. The US has continuously been imposing economic and military

sanctions against Iran for a number of years (Matthew Moore. 2007). Imposing one of the recent bids of US sanctions on Iran, on 25 October 2007, the US Secretary of State Condoleezza Rice accused Iran of "pursuing nuclear technologies that can lead to a nuclear weapon; building dangerous ballistic missiles; supporting Shia militants in Iraq and terrorists in Iraq, Afghanistan, Lebanon and the Palestinian territories; and denying the existence of a fellow member of the United Nations, threatening to wipe Israel off the map" (CNN. 2007). Barack Obama, in his first speech since securing the Democratic presidential nomination, warned Iran to stop its nuclear program. Speaking to the American Israel Public Affairs Committee in the first week of June 2008, Obama pledged "I will do everything in my power, everything, to prevent Iran from obtaining nuclear weapons." (Arutz Sheva. 2008). Earlier, the Republican presidential nominee, Senator John McCain, voiced similar thoughts about Iran saying "There'd be a broad range of sanctions and punishments to the Iranians to help try to convince them that their activities - particularly development of nuclear weapons - is not a beneficial goal to seek" (CNN. 2008). Iran is also rapidly being alienated as the Western Countries and the United Nations, responding to US calls, have also imposed wide ranging sanctions on Iran (Blair, D. 2008).

There are now increased talks of military preparations in the final stages for a strike against Iran. On April 25th, the U.S.'s top military officer, chairman of the Joint Chiefs of Staff, Adm. Michael Mullen, said that the U.S. is planning for "potential military courses of action" against Iran. Similar reports have been aired by the Russian news service RIA Novosti that the U.S. has completed preparations for a military strike against Iran (Rabkin, D. 2008). The recent deployment of the second US aircraft carrier in the region is quite understandable in the context of these policy statements on part of US officials. Robert Gates, the US defence secretary has said the deployment of a second aircraft carrier to the Gulf could serve as a "reminder" to Iran of American resolve to defend its interests in the region. CBS News has also reported that the Pentagon has ordered commanders to explore options for attacking Iran and that the state department was formulating an ultimatum calling on Iran to stop arms smuggling into Iraq (Guardian. 2008) (Khalid, M. 2008).

Iran at the same time remains to be equally defying claiming its nuclear program to be of peaceful nature unlike being interpreted by the US and its allies. Typical characteristics of Iran such as 65 million people with a reasonable qualification level, abundant natural resources (including the second largest oil reserves in the world), reasonable industrial base, near decade-long combat experience in 1980s and a proud history of thousands of years, promise a strong geo-strategic status in the region.

5. Discussion

The Strait of Hormuz is a vitally important international waterway that connects the Persian Gulf with the Gulf of Oman into the Indian Ocean. It is the main passageway for oil exports from the Persian Gulf countries (i.e. Iran, Iraq, Kuwait, Saudi Arabia, Qatar, and the United Arab Emirates) - in 2006, around 17 million barrels of oil traveled through the Strait of Hormuz every day, accounting for 20 percent of the total world supplies. If the discussed threat of a US-Iran military confrontation becomes a reality, it could easily lead to a global socio-economic crisis. With Iran holding a strong geo-strategic position around the Strait of Hormuz secure supplies of oil through the Strait can not be guaranteed. The fears of serious threats to global energy security are supported by statements on part of some of the leading Iranian officials - referring to the possible use of force on part of US against Iran, Iranian officials have time and again threatened that they may resort to the "oil weapon" if necessary. The Iranian threat to exercise "oil weapon" is quite open ended that is generally being interpreted as anything that could be used to stop or hinder the flow of the much-needed oil to the international markets. This could include a wide range of actions that intentionally stop or seriously reduce the flow of oil from the Persian Gulf to the main consumption centers (Diba, A. 2008). Iran's former chief nuclear negotiator and head of the Supreme National Security Council, Ali Larijani, made Iranian intentions in this regard very clear as he said. "We do not want to use the oil weapon. It is them who would impose it upon us... we will react in a way that would be painful for them ... Do not force us to do something that will make people shiver in the cold" (Tisdall, S. 2008). Similarly, Iran's Supreme Leader, Ayatollah Ali Khamenei, has threatened to shut the strait in response to U.S. military pressure. His naval commanders claim to have an array of high-tech weapons including a super-speed torpedoes and a sonar-evading, anti-ship missile (MSNBC, 2008).

Amongst the most prominent likely consequences of the conflict would be disruption in oil supplies through Strait of Hormuz and jump in oil prices. Based upon the fact that in the 1970s, a reduction of supply by just 5% caused a price increase of more than 400%, estimates suggest that a reduction of as little as 10-15% could cripple global economy (Howden, D. 2007). The fact that the discussed US-Iran conflict has a tendency to interrupt supplies as much as over 20%, oil prices can experience even a higher growth to that during the 1970s.

The phenomenon of soaring oil prices coupled with disruption in supplies can also lead to internal unrest and political instability in many countries. It would result into increased gap between rich and poor thus heightening the risk of internal conflict within under developed countries. Those at the top of the economic ladder would be able to procure

basic necessities of life whereas those at the bottom would find access to vital commodities of life such as food and shelter even harder.

In case of similar circumstances created by a shortage of oil supplies, Michael Klare warns that “Poor will find themselves in an increasingly desperate situation – and thus more inclined to heed the exhortations of demagogues, fundamentalists, and extremists who promise to relieve their suffering through revolt or ethnic partition” (Klare, M. 2002). Analysts also warn that the supply shortages could lead easily to disturbing scenes of mass unrest and the situation could spin out of control and turn into a complete meltdown of societies (Seager, A. 2007).

Another crucial implication of the issue would be a stressful food scenario. Already, the soaring fuel prices are being considered partly responsible for the ongoing food crisis- in many parts of the world including USA, Brazil, India and Southern African countries, the growing trend of biofuel production at the cost of food crops is being regarded as one of the key phenomenon's having contributed to the food crisis especially with regards to price hike with wheat, maize and rice.

References

- AFP, (2008). Oil price eases, remains in reach of 140 dollars, http://afp.google.com/article/ALEqM5jrUJXLC54A_9iAuSZKxa_eWbklQ (June 27, 2008)
- Arutz Sheva, (2008). Obama Takes Pro-Israel Stance at AIPAC, Israel National News, <http://www.israelnationalnews.com/News/Flash.aspx/147732> (June 27, 2008)
- Asif, M., Currie, J., & Muneer, T. (2007). The Role of Renewable and Non-Renewable Sources for Meeting Future UK Energy Needs, *International Journal of Nuclear Governance, Economy and Ecology*, 1, 4, 372-383
- BBC, (2008). Oil hits \$108 on pipeline blast, BBC, <http://news.bbc.co.uk/1/hi/business/7316138.stm> (June 27, 2008)
- Blair, D., (2008). UN approves fresh sanctions against Iran, Telegraph,
- Charles Hirschman, World Population Growth: Historical Trends and Future Prospects, <http://www.washington.edu/research/or/symposium/hirschman.pdf> (June 27, 2008)
- Christian Kornevall, Access to electricity, (2004). Report prepared for the ABB Group
- CNN, (2007), US slaps new sanctions on Iran, CNN Politics,
- CNN, (2008). McCain warns of increasing Iranian influence, <http://edition.cnn.com/2008/POLITICS/03/18/mccain.comments/index.html> (June 27, 2008)
- Diba, A., (2008). Iran and Oil weapon, Persian Journal, http://www.iranian.ws/cgi-bin/iran_news/exec/view.cgi/14/16643 (June 27, 2008)
- Energy and Development, World Energy Outlook, IEA, 2004
- Guardian, (2008). Deployment of aircraft carrier a US 'reminder' to Iran, says Gates, <http://www.guardian.co.uk/world/2008/may/01/iran.usforeignpolicy> (June 27, 2008)
- Historical Crude Oil Prices, (2008). Inflationdata.com, http://inflationdata.com/inflation/Inflation_Rate/Historical_Oil_Prices_Table.asp (June 27, 2008)
- Howden, D., (2007). World Oil Supplies Are Set to Run out Faster, The Independent, http://news.independent.co.uk/sci_tech/article2656034.ece (Accessed on June 27, 2008)
- http://www.analyst-network.com/article.php?art_id=2013 (June 27, 2008)
- <http://www.telegraph.co.uk/news/worldnews/1580585/UN-approves-fresh-sanctions-against-Iran.html> (June 27, 2008)
- IEA, (2007). Annual Statistics, International Energy Agency
- International Energy Outlook, (2005). Energy Information Administration
- Khalid, M., (2008). US-Iran showdown in Gulf, Khaleej Times, http://www.khaleejtimes.com/DisplayArticleNew.asp?section=opinion&xfile=data/opinion/2008/may/opinion_may27.xml (June 27, 2008)
- Klare, M., (2002). Resources War: The New Landscape of Global conflict, Henry Holt and Company, New York, p24
- Matthew Moore, (2007), US imposes harsh new sanctions against Iran, Telegraph, <http://www.telegraph.co.uk/news/worldnews/1567327/US-imposes-harsh-new-sanctions-against-Iran.html> (June 27, 2008)
- MSNBC, (2008). Iran's double-edged oil weapon, <http://www.msnbc.msn.com/id/22056178/> (June 27, 2008)
- Muneer, T., & Asif, M. (2007). Energy Supply, its Demand and Security Issues for Developed and Emerging Economies, *Renewable & Sustainable Energy Reviews*, 11, 7, 1388-1413

Muneer, T., & Asif, M. (2007). Prospects for Secure and Sustainable Electricity Supply for Pakistan, *Renewable & Sustainable Energy Reviews*, 11, 4, 654-667

Muneer, T., Asif, M., & Munawwar, S. (2004). Sustainable Production of Solar Electricity With Particular Reference to the Indian Economy, *Renewable & Sustainable Energy Reviews*, 9, 5, 1-30

OPEC, (2008). Oil Market Report, February 2008

Persian Gulf Region, (2008), Energy Information Administration, http://www.eia.doe.gov/emeu/cabs/Persian_Gulf/Background.html (June 27, 2008)

Persian Gulf Region, Energy Information Administration, (2008). http://www.eia.doe.gov/emeu/cabs/Persian_Gulf/Background.html (June 27, 2008)

R. Sims, (2004). Renewable energy: a response to climate change, *Solar Energy*, 76, 1, 9-17

Rabkin, D., (2008), War with Iran: Closer than Ever, International Analyst Network,

Seager, A. (2007). Steep decline in oil production brings risk of war and unrest, says new study, *The Guardian*

State of the World Population, (2007). UNFPA, <http://www.unfpa.org/swp/2007/english/introduction.html> (June 27, 2008)

Statistical Review of World Energy, (2007). British Petroleum

Summit conclusions at a glance, World Development Summit, (2002). <http://news.bbc.co.uk/1/hi/world/africa/2230670.stm>, (June 27, 2008)

The White House, President Delivers State of the Union Address, (2002). Office of the Press Secretary, <http://www.whitehouse.gov/news/releases/2002/01/20020129-11.html> (June 27, 2008)

Tisdall, S., (2008), Iran threatens to use 'oil weapon' in nuclear standoff, *Guardian*, <http://www.guardian.co.uk/world/2006/aug/07/topstories3.iran> (June 27, 2008)

World Population Data Sheet, (2007). Population Reference Bureau, http://www.prb.org/pdf07/07WPDS_Eng.pdf (June 27, 2008)

World Population to Increase by 2.6 Billion over Next 45 Years, (2008). UN Press Release POP/918, <http://www.un.org/News/Press/docs/2005/pop918.doc.htm> (June 27, 2008)

Table 1. Growing trend of urbanization in the world

Year	World population (billions)	Urban population	
		(billions)	% of the world total
1900	1.6	0.22	13.8
2000	6.1	2.8	46.0

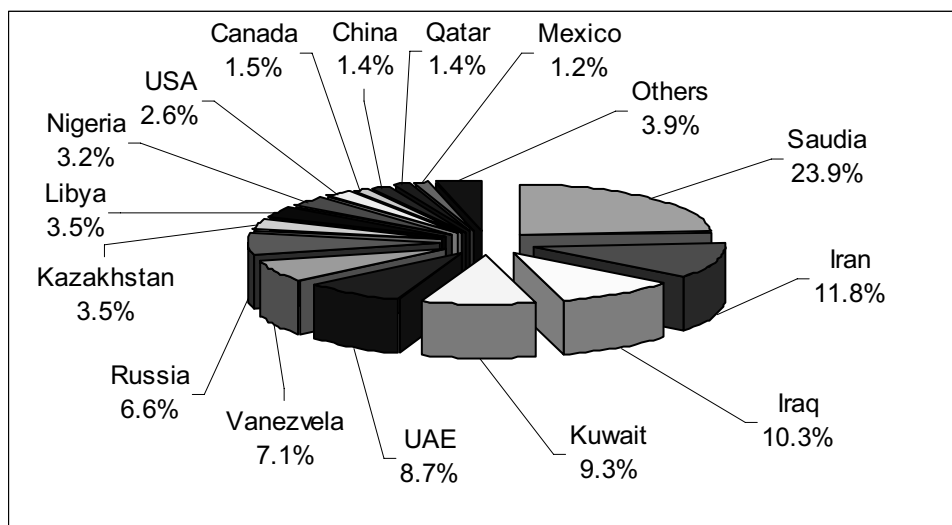


Figure 1. Distribution of Global Oil Reserves

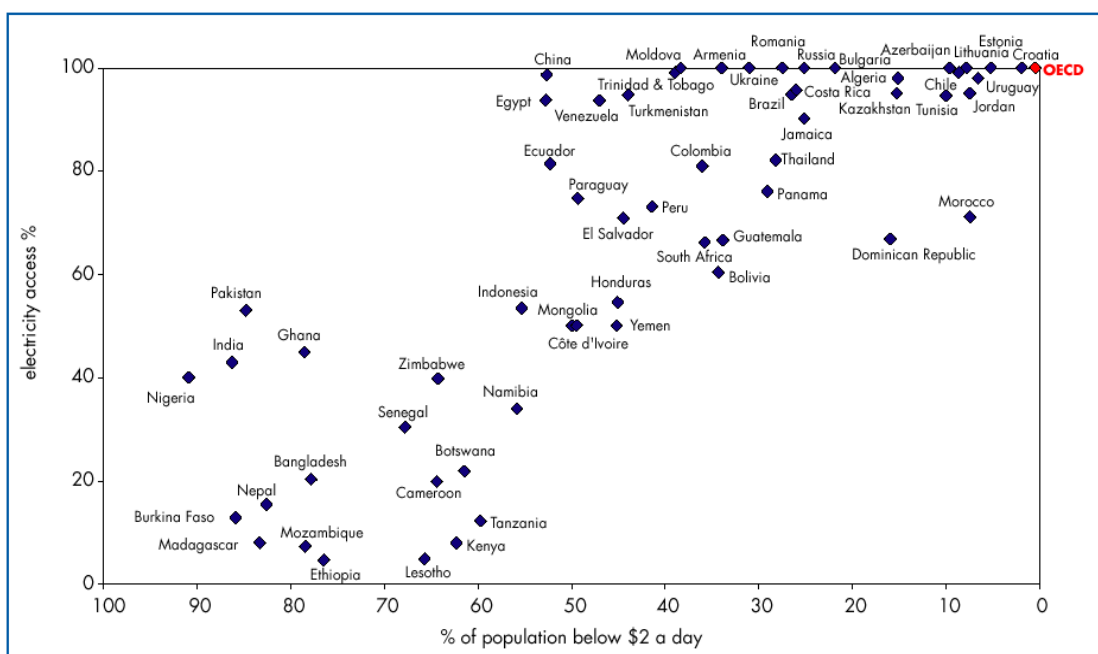


Figure 2. Relationship between access to electricity and economic prosperity

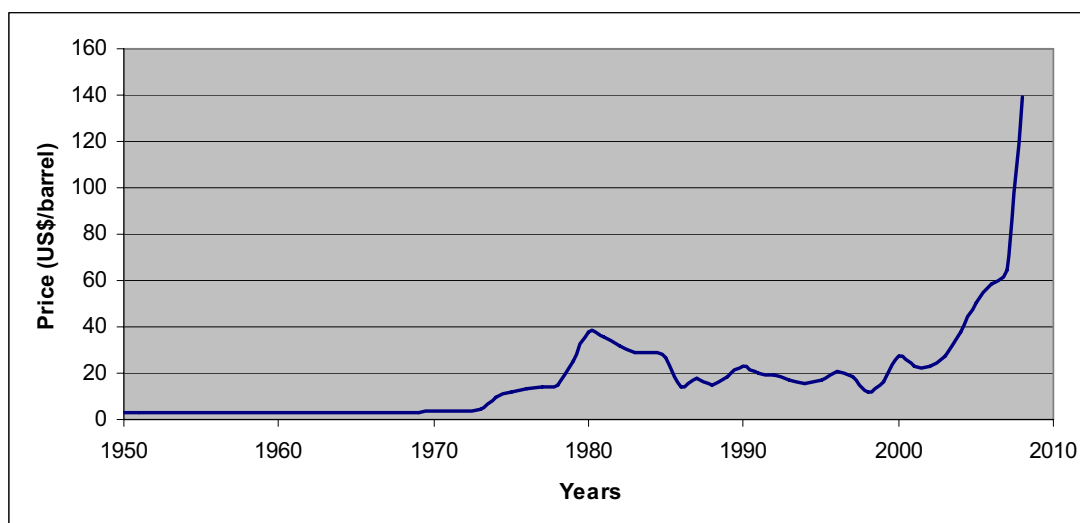


Figure 3. Crude oil prices in historical perspective (nominal)



The Analysis and Counter-Measures Discussion about Information Asymmetry in the Operation and Management patterns of Organic Agriculture -----Based on Comparison between Zhongliangmeiyu Ltd in Heilongjiang Province and Company A in F City, Shandong Province and an Analysis Used SWOT Approach

Xinmin Zhang

College of Economics & Management, China Agricultural University
Beijing 100094, China

Yongfu Chen

College of Economics & Management, China Agricultural University
Beijing 100094, China

Chuncheng Liu

Beijing Central Business District Administrative Commission
Beijing 100094, China

Jialin Xin

College of Economics & Management, China Agricultural University
Beijing 100094, China

E-mail: qchzxm@126.com, chenylf@yahoo.com.cn

Abstract

In This paper, we focus on the need for compares the organic production, operation and management patterns between paddy rice production base of Zhongliangmeiyu Ltd (Meiyu for short) and organic vegetable production base of company A, and adopt the SWOT approach to analyze the strengths, weaknesses as well as external opportunities and threats of the two patterns. The conclusion can be briefed as follows: being located in high-end products market is the premise and basis of China's success in organic production, operation and management, blending cultural factors into production, operation and management is one of effective measures to solve the problem of information asymmetry in the "firm & farmer" operation and management pattern..

Keywords: Organic production, Operation and management pattern, "Firm & farmer" pattern, Information asymmetry

1. INTRODUCTION

This will be followed by a description of China's organic agriculture experiences the process of take-off, quest and development in the recent years. Since 2006, China's organic farming area has been the largest in Asia, the second largest in the world, accounting for 0.6% of total agriculture farming area, about 1560 farms (agricultural firms) adopt organic agriculture production method (IFOAM & FIBL). Restricted with intrinsic factors of mass population and scant per capita arable land in China's rural areas, agriculture production generally have attributes of small-scale and disperse operation. In addition to high production technique standard, authentication cost, market access and risk, single farmer has difficulty with organic agriculture production. Therefore, "firm & farmer" pattern oriented by firm has been one of necessary choices of microscopic operation and management organization in China's organic agriculture production.

In the “firm & farmer” organic production, operation and management pattern, production process of organic agricultural products is organized by farmers themselves. Farmers pursue maximizing individual interest by information asymmetry in the production process, i.e. ,farmers possibly don’t comply with production regulations of organic agricultural products made by “firm” completely ,such as fertilizing and spraying insecticide secretly, in order to increase yield and income. It is obvious that the key problem in the above pattern is how to overcome information asymmetry between single “firm” and mass “farmers”, which means that facing with lots of disperse farmers, it is very difficult for firms to catch hold of every farmer’s production information exactly because of high cost of screening and supervising .

The aim of above problems is to provide methods to construct such probability distribution. this paper selects two different organic production, operation and management patterns of Meiyu in Wuchang city, Heilongjiang province and “A” company in F city, Shandong province, adopts the SWOT approach to analyze the strengths, weaknesses as well as external opportunities and threats of two patterns, and discusses about development tendency of organic agriculture production, operation and management pattern.

2. THE OPERATION AND MANAGEMENT PATTERNS AND THE CHARACTERISTICS OF MEIYU AND COMPANG A

2.1 Meiyu company

Meiyu initially signs organic rice orders with farmers, according to contracts, farmers can only use biological organic fertilizer which is admeasured uniformly by company instead of any chemical fertilizer. However, adopting organic production makes paddy rice yield decrease, so some farmers fertilize secretly in order to enhance yield. In order to prohibit farmers from fertilizing secretly, encourage farmers to use environmental fertilizer according to company’s requirement, and ensure the standardization of organic production, in the beginning of 2008, Meiyu took farmers’ suggestion into consideration, formulated the method of calculating income according to growing area. Farmers grow paddy rice according to organic production regulations strictly, they can receive ¥30,000 per hectare regardless of yield in autumn. The key point of this “lowest income” policy is ensuring that farmers grow paddy rice according to organic production regulations strictly, thus guarantee the quality of organic rice completely.

Meiyu regulates paddy rice production management strictly, employs digital tracing and close “ID” in the whole process to manage products. They provide seeds and technology training closely, allocate nutrient closely, thresh paddy rice closely, quantify electronically in the fields, use uniform packaging specification, sewing standard and attaching “ID”, put into low-degree warehouse directly. Meiyu initiates direct management from field to workshop, solves the quality of organic products concerned by common people, alleviates farmers’ burden.

In the process of exploring organic agriculture production management pattern, Meiyu reflects its corporate culture which advocates Confucianism, aiming at forging high-end rice brand by means of relying on farmers, trying to solve farmers’ practical difficulties and making farmers benefit from the new pattern. Firstly, provide scholarship and stipend for farmers’ children to afford their total or partial tuition. Secondly, pay medical item expense for farmers’ family. Thirdly, offer help to farmers who got poor because of serious illness. Finally, give wedding money to farmers’ children when they are married. In addition, Meiyu provides farmers legal assistance. The culture construction of Meiyu caught hold of farmers’ hearts, combining farmers with enterprise, forming the unity of interest.

Meiyu is going to integrate agriculture industrialization, enhance farmers’ living standard, combine new countryside construction with its development, try to improve farmers’ living environment and quality. Meiyu is planning to establish Zhongliangmeiyu organic paddy rice cooperative, in the principle of voluntary participation, evaluating farmers’ present residence, determining capital stock according to real value as original stock of joining into cooperative. Later on, Meiyu company would take down old housing, program and design new farmers’ villa uniformly, improve farmers’ housing condition radically.

From the above we can see that Meiyu blends traditional culture into management on the basis of cooperative pattern, unifies interests of firm and farmers by “common people’s hearts” project, stimulates farmers’ production enthusiasm, makes farmers implement organic production management regulation spontaneously, avoids information asymmetry problem effectively. The pattern is entitled “common people’s hearts” management pattern. In the meanwhile, Meiyu locates themselves in domestic high-end organic rice market, supports high input cost with high profit margin. It undertakes all production and marketing risk, satisfies farmers’ needs of evading risk, gets rid of farmers’ opportunism inclination, guarantees organic products’ quality. Its successful experience is :putting forward Confucianism as its corporate culture, focusing on “common people’s hearts”, integrating farmers with firm, making farmers engage in paddy rice production management spontaneously, combining strengths such as capital, technology and market & base with natural resources, labor resources, realizing strengths complementation and resources sharing.

2.2 Company A

Company A is one of export-oriented joint ventures founded in 1994, which operates growing, processing and exporting of organic vegetables. Over these years, “A” company promotes base construction positively in the principle of

“Constructing market-oriented base, introducing standard to manage base”. They arrange planting plan, supply means of production and seed, purchase organic raw material, train operators uniformly in order to guarantee organic products’ quality.

The scope of this research lies in company A popularizes several patterns such as “firm & base & farmers”, “firm & cooperative & farmer”, spending more than ¥800,000 on base construction reform and farmers’ income loss subsidies. In the beginning of 2008, we investigated an organic vegetable production base of “firm & cooperative & farmers” pattern. Its main attributes of production, operation and management can be briefed as follows: unify interests of firm and farmers, acquisition process and production management mainly rely on cooperative, firm assigns technical to help cooperative to instruct farmers’ production, arranges growing plan, supplies means of production and seeds, purchases organic agricultural products uniformly according to previously agreed price. As for some farmers’ information asymmetry (opportunism tendency), “A” company performs “ten households unity”, if only one family offends regulation, others would be punished together, aiming at supervising each other among farmers.

From above point of view that we can see that company A lets cooperative sign production contract with farmers, cooperative performs united punishment management against organic production and operation, which is entitle “United punishment” management pattern. At the same time, “A” company locates in organic vegetable export market, relatively high international market price makes company A supply higher organic price than common vegetable, making up for the loss of production cost increase and yield decrease, ensuring farmers’ high income. Company A’s potential risk is relatively low, its main risk comes from international market, while farmers undertake main production risk. Firm and farmers are connected by economic interest, production, operation and management cost is low, supervise farmers with punishment measures, but information asymmetry problem between firm and farmers can’t be eliminated completely.

3. THE SWOT ANALYSIS OF ORGANIC PRODUCTION, OPERATION AND MANAGEMENT PATTERN

3.1 The SWOT Analysis of Meiyu company’s organic production, operation and management pattern

a. Strength

1) Harmony

Firstly, Meiyu major shareholders are Wuchang citizens, they have good interpersonal relationship and the goal of benefiting hometown, so they can easily receive help from local residents and government, which reflects China’s cultural tradition. Secondly, Wuchang city has a long history of growing rice and abundant labor forces, farmers have rich experience in growing rice. All these provide basis for this labor-intensive product.

2) Local deeply cultural tradition establishes the basis of “common people’s hearts” management

The name of Wuchang city comes from China’s traditional culture, especially from Confucianism. China’s traditional culture advocates “repay others more for their previous help”, Meiyu corporate culture has strong cohesion. From the survey we can see that local farmers’ production enthusiasm is very high, attaching importance to company’s reputation. Traditional rural society has little liquidity, farmers’ living scope is narrow and fixed, and people concern about others’ attitude towards themselves, which is one reason of Chinese people’s being concerned about face-saving. Zhongliangmeiyu company groups farmers, lets them supervise and promote each other, and makes organic production management become farmers’ own things. All these are culture characteristics of Meiyu organic production management, catching hold of “common people’s hearts”, transforming organic production management into farmers’ spontaneous actions.

3) High efficiency and good effectiveness of production, operation and management

“lowest income” policy transfers the risk of organic paddy rice production to firm, farmers don’t burden production risk, saving supervising cost, eliminating some farmers’ opportunism tendency. In the pattern of Meiyu organic production, operation and management, farmers are major forces, they can arrange their labor time freely and reasonably, saving supervising cost, enhancing production efficiency.

4) Receiving support from local government

Meiyu combines corporate development with new countryside construction, which is not only favorable for farmers but satisfies local government’s need of setting new countryside construction example. As a result, local government supports Meiyu development greatly.

b. Weakness

1) Starting late, pattern of production management needs to be improved further

At present, farmers approve of firm’s principle of “calculating income according to growing area”, production enthusiasm is high. But from the long term, there is no relationship between yield and farmers’ income. It is necessary

to establish long-term incentive mechanism, improve pattern of production management further in order to keep farmers' enthusiasm.

2) Firm undertakes almost all risk, too much upfront input

Meiyu risk of production management pattern focuses on itself, upfront input is enormous, requiring strong power backing up. Market development is a long-term process, consuming high marketing expense, so operating benefit is low, profiting is difficult at the beginning. Meiyu company's real operation condition proved it: firm sank into deficiency in 2007, its general manager—Mr.Zhang, analyzed that even if break-even is god-given in 2008.

c. Opportunity

Domestic organic food market is developing increasingly, organic food is accepted by common people gradually. China's economic growth and income increase expand space for high-end organic rice brand development. Meiyu locates in "developing organic rice, forging high-end organic rice brand", competing with Japan's "Yueguang" rice, its series of products' lowest sales price is ¥34 per kilogram. High profitable space provides basis and guarantee for firm's benefiting farmers and implementing "common people's hearts" management.

d. Threat

It should be noted that domestic organic food market isn't normative, "Bad money drives out good" phenomenon is serious, consumers are suspicious of organic agricultural products, which is harmful to organic food market's healthy development. Japan's rice entered domestic market aggressively and occupied our high-end rice market rapidly, which makes China's high-end rice market's competition excessively fierce.

3.2 The SWOT Analysis of company A's organic production, operation and management pattern

a. Strength

1) Management system is relatively perfect

Through long-term cooperation, firm and farmers trust each other step by step. Through many years' exploration, organic production, operation and management system is improved and developed gradually.

2) Firm only undertakes a little risk and input

Owing to adopting order form, price is determined previously, quality standard is decided by firm, production risk is born by farmers instead of firm. Uniformly supplied means of production's price is decided by firm, freedom degree is high, cost is burdened by farmers, firm only advances in the short-term.

b. Weakness

Concerning general aspects of information asymmetry, high production supervising cost, it's difficult to eliminate farmers' opportunism tendency. One difficulty of company A's organic production, operation and management pattern is prohibiting farmers from fertilizing and spraying insecticide secretly in order to increase yield. Some farmers' opportunism tendency affects organic agricultural products' fame seriously, leading to consumers' suspicious of organic agricultural products' quality, doing harm to healthy development of organic agriculture.

c. Opportunity

Company A is export-oriented, mainly exports to Japan, the USA, Canada. In the following of "green barrier" in Japan, exporting common agricultural products is increasingly difficult, which yet offers more opportunity for organic agricultural products. All these are beneficial to expand production, reduce management cost, guarantee finishing orders, lower firm risk.

d. Threat

There are more and more organic vegetable manufacturing firms joining into export army, export competition is increasingly fierce, price is increasingly lowering, market risk is growing.

4. CONCLUSION

Through the comparison and a SWOT analysis of the organic production, operation and management patterns between Meiyu and company A, we can know that these two patterns have their own strengths and weaknesses, opportunities and challenges.

Meiyu's paddy rice production and management pattern is an innovation to "firm & farmers" by the pattern of operation and management. Its main success experience are following: making use of culture construction, focusing on "common people's hearts" management, linking farmers with firm, making rice production and management become farmers' spontaneous behaviors, guaranteeing organic agricultural products' quality, laying foundation for forging high-end rice brand. This pattern is an effective way to solve some farmers' opportunism tendency in "firm & farmers" pattern, ensuring production quality of organic agriculture effectively. However, organic vegetable production pattern of

company A links firm and farmers by economic interest, which cost is lower of production and management, supervises farmers by means of punishment, farmers' opportunism tendency is difficult to eliminate. In addition, firm undertakes little investment and risk. As a result, the majority of organic agriculture firms would choose this pattern.

Indeed, operating strategy play a important role in management section. Meiyu locates in "developing organic rice, forging high-end organic rice brand", competing with Japan's "Yueguang" rice, its series of products' lowest sales price is only ¥34 per kilogram. High profitable space provides basis and guarantee for firm's benefiting farmers and implementing "common people's hearts" management. The key point of forging high-end organic rice brand is to guarantee stable and high products quality. This pattern lays solid foundation for long-term cooperation between firm and farmers, ensuring win-win situation. In the innovation of organic production and management pattern, firms are major force of resource integration, leading enterprises are key to organic production and development. Meiyu combines strengths such as capital, technology and market & base with natural resources, labor resources, realizing strengths complementation and resources sharing. While company A locates in international market, combines farmers with firm by means of "firm & farmers" pattern, which makes company A get development rapidly. However, owing to information asymmetry, once farmers have opportunism tendency, it would be harmful to firm's honor, which sharply increases firm's risk. Though "United punishment" management pattern possesses strength of low operation and management cost, it is troubled with ultimate problem of keeping long-term and sustainable development.

Form the above discussion, the conclusion can be reached that being located in high-end market is the premise and basis of China's success in organic production, operation and management, blending cultural factors into production, operation and management is one of effective measures to solve information asymmetry problem in the "firm & farmer" operation and management pattern.

References

- CAO, Hui, CHEN, Ping-liu. (2007). The Study of Swot Analysis and Countermeasures on Development Flower Industry in Fujian Province. *Yunnan Geogaphic Environment Research*.2007.03, pp. 79-83.
- Deng Hongtu, (2004). A Historicist Interpretation of Firm Integration and the Pattern of Company Linking With Farmers & Production Bases—Evidence from the Contracts between Saiyafei and Farmers. *Research of Institutional Economics*.2004.02, pp. 122-140.
- Jia Weiqiang, (2007). *Research on Cooperation mechanism of Company & Peasant Household Pattern*. JiangXi People's Publishing House. 2007.08, pp. 4-6.
- Ma, Zhuo. (2006). Development, Question and Countermeasure of Organic Agriculture in China. *Chinese Agricultural Science Bulletin*. 2006.11, pp. 338-342.
- SUN, Yaowu, Liu, Cao. (2004). Economic Analysis on Operation Difficulties of "Corporation & Farmer" Organization. *The Theory and Practice of Finance and Economics*. 2004.04, pp. 113-118.



The Relationship between Poverty, Conflict and Development

Brian-Vincent IKEJIAKU

Research Institute for Law, Politics and Justice

Keele University

Keele, Staffordshire, ST5 5BG, UK

Tel: 44-7944-765-923 E-mail: ike.bvo06@yahoo.com

Abstract

Contrary to the expectations and dreams nourished by many people that the end of the 'Trio-Crisis Initiators' in Africa: Colonialism (1960s) Cold War (1998) and Apartheid (1994), will bring stability and succour to the continent, however, the new era could as well be perceived as a turbulent period. This paper establishes the relationship between poverty, conflict and development (PCD) in analysing instability in the African continent. In its analysis, the paper examines several variable factors that can help in the explanations of the relationship between PCD in Africa. These variable factors includes: economic, political, population, climate and environment, ethnic composition, militarization, poor growth and political corruption. None of these varying factors can unilaterally explain the relationship between poverty, conflict and development as issues behind Africa's instability. However, the paper argues that political corruption stands out as the most persuasive, compelling and primary explanation for the (causal) relationship(s) between PCD, though, it is not an exclusive one. While, the paper recognises that there are both exogenous and endogenous trends that influence political corruption, the paper adopts the endogenous (domestic political corruption) perspective, because political governance is now more controlled at home. The paper employs the human needs theory for analysis.

Keywords: Democracy, Poverty, Conflict, Political Corruption, Development, Growth, Human Needs Theory

1. Introduction

The African continent over the past three decades, particularly in the 1980s and 1990s has faced greater challenges to stability and progress in all ramifications than ever before. The continent is poor; Oputa (1994) tends to suggest that socio-economic conditions of the Africans have little or no impact on the welfare of the people. In spite of the fact that the African continent exceeds in its size and natural resources the combined territories of Europe, the United States and China, yet most Africans must struggle for bare survival (Seidman et al, 2006). That is absolute poverty: '*poverty qua poverty*', the term I coin to describe the practical absolute poverty of Africa, particularly Sub-Saharan Africa where the majority find life excruciating because it is difficult to meet or satisfy their basic needs, such as food, clothing, shelter and education beyond primary school level. It is pathetic that an average African has grown poorer over the past decades, notwithstanding enormous aid disbursement and substantial gains in technology and trade that have helped boost growth in other regions, particularly on the Asian continent (Schaefer, 2005).

In much of Africa, very little economic growth has occurred over the past fifty years. Some countries are even poorer today than they were thirty years ago. Sub-Saharan Africa has had the lowest Gross Domestic Product (GDP) for decades. Statistics confirm that Africa has a population of about 600 million, more than double that of the United States, yet it is estimated that average real GDP per capita growth is 11% in Africa, which is lower today than it was in 1970. Evidence shows that 200 million Africans have no access to proper health care, and proper hygiene. Another 47% are without access to safe water. In some parts of Africa the power supply is constantly interrupted or almost non-existent (Marke, 2007: 1). The Economist (in Wrong, 2004) estimates that 40 percent of the region's privately held wealth is held outside the region. Green and Seidman (1968) argue that there has been structural imbalance in African economies, compared to other regions. It may be contended that this view has been overtaken by time; yet, The World Bank (2005) notes 'Sub-Saharan Africa is the world's poorest continent, with nearly half of its 719 million people subsisting on less than dollar US \$1 per day'. The statistics from the latest MDGs Assessment (UN 2007) that poverty has declined in a number of African countries, does not exonerate Africa from being far the most poverty stricken continent in the world. It is because of Africa's predicament that made Ali Mazrui (in Fapohunda, 2002) one of the most celebrated African writers to assert that Africa is the first home of mankind, yet the last to be made truly inhabitable in contemporary world as a result of poverty and underdevelopment. In fact, the common problem of poverty in Africa is a clear case of '*res ipsa loquitur*' (meaning the matter speaks for itself), particularly in the Sub-Saharan Africa.

Again, the countries of Africa, particularly those in Sub-Saharan Africa are a volatile mix of insecurity and conflict. The problem of conflict and insecurity is destabilising the continent's peace process. It is right to argue that no continent that is bedevilled with the problem of peace and stability in its societal milieu could progress. Thus, the dire need for peace in the African countries is a matter that calls for great and urgent concern. This submission is given credence by the views expressed by Solomon and Wart (2005: 4), on African Peace and Security:

Territorial disputes, armed conflict, civil wars, violence and the collapse of governments and ultimately the state have come to represent the greatest challenges to peace, security and stability. On the African continent, these threats have been much more pronounced and indeed have taken on a scale, intensity and frequency that have defied even the imagination of the greatest science fiction.

The fact is that whenever conflict occurs, the development of the society in most times is seriously affected. As Wanyande (1997: 1-2) discloses the costs of conflicts in Africa in terms of loss of human life and property, and the destruction of social infrastructure are enormous. For example, between 1998 and 2002, some four million people died in the civil war in the Democratic Republic of Congo (Report of the Commission for Africa (RCA), 2005: 107). Besides, once conflict occurs, scarce resources are inevitably diverted to the purchase of military equipment at the expense of socio-economic development. While many factors contribute to creating conflicts, this study claims that African conflicts are mainly as a result of 'poverty rooted on political corruption'. Gurr and Marshall (2003) argue that most African conflicts are caused by the combination of poverty and weak states and institutions, and these have had a devastating impact on Africa's development.

The implication of the above discussion is that there appears to be a link between poverty, conflict and development in Africa. This paper aims to reveal that poverty rooted on political corruption is the major cause of Africa's conflict, and this has led to poor development. This study proposes among other things that the denial of basic needs (poverty) by irresponsible governance in most African states have been at the heart of conflict, as well as the continent's development problems. This study therefore pinpoints political corruption as the root of poverty in Africa.

This paper will specifically consider the following issues: Conflict and some of its effects in Africa, political corruption in Africa and political corruption as a causal explanation for the relationship between poverty, conflict and development in Africa. The use of 'Africa' in this paper is solely for clarity, and therefore means the conflicting countries of Sub-Saharan Africa.

2. Theoretical Approaches to Poverty and Conflict in Africa:

Poverty is a multidimensional problem that goes beyond economics to include among other things, social, political, and cultural issues. Scholars have been trying to develop a theoretical approach to poverty and conflict for a long time. Some like John Burton (1997), Laune Nathan (2003), Richard Sandbrook (1982) and Ted Gurr (1970) agree that poverty as a result of lack of human needs lead to reactions that result in conflict. The human needs theory championed by Burton (ibid) argues that there are conflict and instability in developing countries because people are denied not only their biological needs, but also psychological needs that relate to growth and development. The overriding importance of this theory is that it understands that needs, particularly basic needs (such as food, water, shelter and health) unlike interest cannot be traded, suppressed, or bargained for; thus any attempt to do this, leads to conflict. According to Aristotle (in Okanya, 1996: 3), social strife and revolutions are not brought out by the conspiratorial or malignant nature of man, rather revolutions are derived from poverty and distributive injustice. Therefore, when the poor are in the majority and have no prospect of ameliorating their condition, they are bound to be restless and seek restitution through violence. No government can hold stability and peace when it is created on a sea of poverty (Ibid).

In Africa the case is that of absolute poverty (*poverty qua poverty*). This means that lack of basic needs (like food, clothing, shelter and health) in Africa is the seed of conflict (though, as a matter of emphasis – all African countries are not equally poor and equally conflict prone). '*Poverty qua poverty*' is a situation no human being would be contented with, because of the agonising pains that follow the lack of these basic needs. Therefore, people in most cases react negatively to such situation, in order to show their grievances and discontent, particularly when the government is corrupt. Conflicts are therefore often caused by an attempt to clamour for these basic needs by violent means. Africa, as a volatile mix of poverty and conflict has continued to be poorly developed. Thus, as long as absolute poverty (which is rooted on political corruption) remains in Africa, conflict is inevitable. The argument of this study is that poverty, conflict and underdevelopment in Africa are traceable to political corruption. Hence the question, how can Africa develop politically (particularly by eliminating political corruption) in order to effectively alleviate absolute poverty; in effect manage conflict in Africa to avoid further human losses? Is development possible in Africa, as the continent is embroiled in conflicts?

It is important to point out that there other theoretical strands, beside the Human Needs Theory (HNT), which can be employed for analysis of PCD in Africa. These include dependency theory, international liberalism and modernisation

theory, but HNT is adopted because the paper finds it most relevant for analysing basic needs, which is its concentration.

3. Brief Theoretical Analysis and Explanatory Factors for conflict in Africa:

3.1 Modernisation, democratisation and colonisation

Scholars have emerged with different theoretical explanations for the causes of conflict in Africa. In the face of present crises in Africa, the flaws underlying both modernisation and democratisation theories and the theory of colonialism are being exposed. The long held notion that modernity would result in smooth transition from authoritarian system to democratic system, with gradual elimination of conflict has failed woefully in Africa (Irobi, 2005: 2). Again, the view that the end of colonialism (1960 onwards) – the theory that the end of social, political and economic control of the developing countries by the advanced capitalist nations, particularly the colonialists (Abbah, 1996: 6), would lead to peaceful African states did not stand, as Africa has been besieged with plethora of conflicts since the end of Colonialism.

3.2 Economic

The proponents of economic theory contend that the propensity to indulge in violent conflict is higher for low income or less educated people (Ehrlick, 1973: 521-26). A corollary of this position is that poor economic conditions and low quality of life could serve as a breeding ground for conflict. However, for the fact that poor economic conditions might result from different problems bedevilling Africa, economic factors could not fully explain conflicts in Africa. For example, Glaeser (2002) argues against economic factors noting that political leaders often encourage individuals and groups to engage in violence conflict in order to promote and project their parochial and egocentric interests.

3.3 Militarisation

Militarisation has also been employed to explain the cause of conflict in Africa. The exponents of this theory argue that violent conflict in Africa could be understood in the series of military weapons that have been employed in devastating and disintegrating many developing countries, particularly in Africa. Mohammed (1999: 1) for example argues that the intensity and frequency of civil wars in developing countries have increased unabated throughout the 1990s. However, Omitoogun (2004: 3) argues that in associating militarization and conflict, caution needs to be taken because rather than the proliferation of arms in the society, it is the welfare-reducing effects of militarisation that causes violence. Besides, when it is appreciated that developed countries with more sophisticated arms than Africa are not in conflict like the later, militarisation as an explanation becomes weak.

3.4 Ethnicity

Ethnicity is another crucial explanatory tool to the continent's plethora of conflicts. Theorists believe that ethnicity underlies virtually all conflicts in Africa, since ethnic groups in their bid to compete for scarce resources such as property rights, jobs, education, and social amenities engage in violence. In his study Nnoli (1980) employed empirical evidence associating conflict to ethnic problems. However, Elbadawi and Sambanis (2000: 1) questioned the ethno-cultural and linguistic explanation for conflict in the continent, rather linking Africa's conflicts to other factors – poverty, absence of democratisation and over dependence on natural resources. Collier (1997) argues that Africa is not inherently prone to war as a result of ethnic disparities, but the continent's experiences of many wars, is fundamentally because it is poor and poverty is both the cause and consequence of Africa's wars.

3.5 Population

Population is another important factor to African conflicts. It is argued that there has been tremendous increase in the population of developing countries, which has superseded economic growth. According to the RCA (2005: 112), between 1980 and 2002, the population of Sub-Saharan Africa has grown from 383 to 689 million people, which is an increase of 80 percent. In contrast, in much of Africa, very little economic growth has occurred over the past fifty years. For example, no other region of the world more urgently needs economic growth. However, instead of the desperately needed economic growth, Sub-Saharan Africa as a region has seen a decline in per capita GDP from \$575 in 1980 to \$524 in 2003 (World Bank, 2005, in Schaefer 2005). Some countries are even poorer today than they were thirty years ago. Sub-Sahara Africa has had the lowest Gross Domestic Product (GDP) for decades (Marke, 2007: 1). Supporters of this explanatory tool therefore argue that high population growth has made things difficult in developing countries, as people have to scramble for available resources, which results to conflicts. However, countries like India, China and others have larger populations than most African countries, but they are not in violent conflicts like Africa.

3.6 Volatile climate and environmentalism

The argument that African conflict is as a result of volatile climate and elementary forces (such as drought and famine) in its environment that have affected growth, has been challenged by scholars. Sen (1999: 61-63) for example argues that famine, drought and related disaster are not allowed to occur in democratic polities because people have established mechanism to compel governments to address their needs and pressing problems. Also, Wisner (1988) argues that

drought and other environmental problems cannot directly explain the 1986 disaster that hit 13 African countries since ten of these thirteen affected countries have experienced other problems such as war, civil strife, destabilisation (including apartheid) and a massive influx of refugees.

3.7 Political corruption

Trends of events in the past three decades reveal that political corruption is the 'root' cause of conflict in Africa. The contention here is that political corruption by sapping the economy of Africa renders the continent poor or worsens its poverty situation. And this renders most of the states in the continent incapable of providing the basic needs of the people. Burton's (1979, 1997) human needs theory on conflict and conflict management recognises the indispensability of these needs, by pointing out that wherever such non-negotiable needs are not met, conflict is inevitable. Since political corruption is perpetrated by leaders entrusted with a nation's coffers, the masses normally react by engaging in violence. According to the United Nations Human Development Report (in Fapohunda, 2002: 26), sixty percent of Africans live in abject poverty. The problem of poverty is compounded by the issue of corruption of the state resources, 37% of Africa's assets are held abroad; Fapohunda (Ibid) argues that this figure, the highest for any region in the world, was more of the fruit of corruption. Egbo (2002: 289) maintains that,

'this is public money siphoned overseas by corrupt political and military rulers for their personal use, the problem of poverty and breakdown among most third world countries has its root in the illegitimate and arbitrary methods of these men... the growth of the society becomes stunted'.

While all these competing factors are useful in the explanations of the rise in conflict in Africa, this paper sees political corruption as the most persuasive. In other words, while all these factors contribute to conflict in Sub-Saharan Africa, political corruption is the most compelling.

4. Conflict in Africa and its consequences:

Africa has been experiencing a plethora of conflicts endangering the continent's international order and development over the last three decades, particularly in the 1990s. Africa could be said to have witnessed four major types of conflicts, these include secessions, civil wars, regional conflicts, and internal crises.

Secession is a situation whereby a particular region, community or enclave strives to separate or withdraw from a state's control or authority; that is an attempt to withdraw from a state's sovereignty and organise its own government and separate institutions. Biafra's dogged efforts to secede from Nigeria (1967), the notorious Katanga rebellion in Congo (now DRC 1970s), are notable examples. Usually, the seceding entities pursue autonomy, instead of formal or total independence.

Another form of conflict is civil wars (wars between government state army and the armed forces of a rebel government); these usually start as minor internal crises, but develop to fully fledged war, which are fought with conventional weapons. Although, it is extremely difficult to draw a line between civil war and regional or international wars, many civil wars have been connected with regional or inter-state conflicts. Countries in Africa, particularly those in the Horn of Africa, and for example Democratic Republic of Congo (1998-03), Somalia (1998), Sudan (since 2003), Angola (1975-02), Rwanda (1990-94), Kenya (1991/92, 1997), Ethiopia and Eritrea (1998-2000) and others have all involved in civil wars (Wayande, 1997)). Salih (1999: 141) observes that:

The states and peoples of the Horn of Africa have duly been compelled to choose between total collapse through civil wars or political survival with an uncertain future...

Regional conflict in the continent has been classified as being 'irredentist' (Ruiz, 1997: 1) in character. Conflict is termed as being irredentist when one country harbours some territorial ambitions over another country. Good examples of this form of conflict in Africa include the Somali claim on the Ogaden region of Ethiopia (in early 1970s), and Libya's strive to annex part of northern Chad (early 1980s). The case of Tanzania and Uganda (1979) is a similar conflict, since Tanzania (under President Julius Nyerere) projected its forces over Uganda, in a bid to oust the Ugandan leader (President Idi Amin). Also the combined efforts by some African countries in overthrowing the Mobutu Sese Seko's government in Zaire (1997) are yet other regional conflicts (Wayande, 1997).

Internal crises here mean disturbances of any kind which affect the state of peace and security, these among others include rampages, riots, and violent demonstrations. The Soweto riots in apartheid South Africa in 1976, Fanatical cult killings in March 2000 associated to the movement for the restoration of the ten commandments of God, also the Bryanda riots of 1994 (in Uganda), and series of students' riots in Nigeria between 1999 and 2006 are germane.

Conflict has destabilised most African countries, Wanyande (1997: 1-2) discloses that the costs of conflicts in Africa in terms of loss of human life and property, and the destruction of social infrastructure are enormous:

Hundreds of thousands of people have been killed in many of the countries in which the conflicts occur. Many others have also suffered and continue to suffer untold psychological trauma associated with conflicts... once conflicts occur,

scarce resources are inevitably diverted to the purchase of military equipment at the expense of socio-economic development (Ibid).

The Report of the Commission for Africa also notes that conflict causes as many deaths in Africa each year as epidemic diseases and is responsible for more deaths and displacements than famine or flood. When people are forced to flee their homes, poverty associated ailments such as malnutrition and diseases follow. Those who suffer most from conflicts are the poor and vulnerable, including children and women. Statistics reveal that there are 13 million displaced people in Africa, particularly due to conflicts and 3.5 million refugees (RCA, 2005: 107). Example includes Northern Uganda (2005), Kenya (1991/92), Rwanda (since 1994) and others. Making brief reference to the report of the commission of Africa (Ibid):

Out of sight of the world, in the biggest death toll since the Second World War, around 1,000 people die every day in the Democratic Republic of Congo. It is only one of Africa's many conflicts. In recent decades Africa experienced more brutal coups, drawn ...and bloody instability than any other part of the world.

The costs of conflicts are horrific, and in many cases conflicts wiped out the achievements of decades of economic and social development. Armed conflicts, in particular, involve complete economic paralysis, immense social costs and trauma, political quagmire and disintegration, as well as serious environmental degradation and dilapidation.

The RCA (2005: 161) also notes that some conflicts, like violence in Darfur, have been of high intensity, however, it observed that 'there are countless smaller conflicts, such as those between herders and cultivators that are to be found in many parts of Africa, which are no less vicious'. Violence from these smaller conflicts also causes as many deaths in Africa as do diseases. For example, the human cost resulting from localised conflicts is devastating, since many are even sent to a 'state of limbo':

Millions of lives have been lost... As a result of 'localised' conflict in Nigeria, for example, at least 10,000 people lost their lives between 1999 and 2003, and an estimated 800,000 were internally displaced. More people have been forced to flee their homes in Africa than anywhere else in the world; many ending up in the slums of already – over crowded cities and towns. Malnutrition and disease increase. And those who suffer most are the poor and the vulnerable. War and conflicts does not only harm people. It destroys roads, bridges, farming equipments, telecommunications, as well as water and sanitation systems. It shuts down hospitals and schools. It slows trade and economic life, sometimes to a halt. The very fabric of society is torn asunder (RCA, 2005: 38).

The consequences of conflicts are much wider; conflict also weakens the stability of Africa and even extends its 'destructive tentacles' to global peace – 'instability in Africa undermines global security. States weakened by strife increase international refugee flows. They also become havens for international terrorist organisations...' (RCA: 38). In these ugly trends, it may seem odd to talk of optimism in most African countries where conflicts have become common, as in Nigeria (since 1985), apartheid South Africa (1948-1994), Mozambique (1976-1992) and DRC (1996-2001); others include Sudan (1983-2003), Somalia (1981-2002), Sierra Leone (1991-2000), Liberia (1989-2003) Rwanda (1990-ongoing), Burundi (1991-ongoing), Angola (1975-2002) and host of other African countries (Uppsala, 2003).

5. Corruption in Africa

The magnitude of corruption in most African countries, to say the least is alarming, terrific and disheartening. Corruption by political leaders has been identified as one of the major causes of poverty, and the failure in the development of developing countries, particularly in Africa. The incidence of corruption remains one of the greatest challenges of democracy in the continent as virtually all democratic experiments are associated with reports of hyper-corrupt practices (Okafor 2004: 98). The embezzlement of public funds by unscrupulous and ineffective leaders of most African countries leads to poverty, high debts and other socio-economic associated problems in these countries.

For instance, focusing exclusively on the top leadership, Transparency International estimates that Mobutu in Zaire and Abacha in Nigeria may have embezzled up to US \$5 billion each (in Azmi, Daily Times 2005). According to Global Witness (in Ibid), several current leaders in Africa are plundering their own treasuries. Among them are Angola's President Jose Eduardo dos Santos, who it says keeps large sum in bank accounts abroad, and Equatorial Guinean President Teodoro Obiang, who calls oil revenues a 'state secret'. The Mwai Kibaki government in Kenya, which ousted President Arap Moi in an election in 2003, is investigating embezzlement to the tune of \$1billion by former officials, the notorious 'African Big Man' the late President G. Eyadema of Togo was very corrupt.

Campbell (2004) observes that Billions of pounds, enough to pay for the entire primary health and education needs of the world's developing countries are being siphoned off through offshore companies and tax havens. Aid organisations are alarmed that money which should be used for building the infrastructure of the poorest countries is being hidden in the havens by corrupt politicians and multinational companies exploiting tax loopholes (Ibid). In 1999, *The Economist* (in Azmi, 2005) estimates that African leaders had \$20bn in Swiss bank accounts alone, twice the amount that Sub-Saharan Africa spends on servicing debts. A recent piece of research reveals that there was a high level of

corruption in South Africa, particularly during the apartheid period. The apartheid government was a corrupt system of governance, in summary:

A near monopoly on money, power and influence were in the hands of a minority and they used this to either violently suppress the majority or, at least, transfer resources in order to stave off the inevitable revolution (Vuuren, 2006: 37).

Further more, roughly 3,000 member of African elites (the majority present and former political leaders), had Swiss Bank accounts totalling 33 billion dollars. One high official even owned a bathtub made of solid gold (Dorman, 1993: 10). In spite of these monumental accumulations, 'these factionalized neo-patrimonial African elites still do not constitute an ascendant bourgeoisie. They have neither the will nor the independent power base to enforce productive priorities or discipline upon the state apparatus' (Okafor, 2004: 99); thereby making poverty alleviation, peace and sustainable development far from realisation in most African states. There is no comparison for corruption in Africa with those of other regions. In analysing political corruption with regard to its relationship to the different rates of economic development in Africa and Asia, an excerpt from the *Economist* (in Calendar online 2007) is telling:

One of the factors behind the differing economic development in Africa and Asia is that in the former, corruption has primarily taken the form of rent extraction with the resulting financial capital moved overseas rather invested at home (hence the stereotypical, but sadly often accurate, image of African dictators having Swiss bank accounts)... In contrast, corrupt administration in Asia like Indonesia under Suharto's have often taken a cut on everything... but otherwise provided more of the conditions for development, through infrastructure investment, law and order, etc.

The implication of the above statement is that political corruption in Africa impacts negatively to the economic development because African leaders rather than investing their stolen wealth in the continent (like their Asian counterparts), stash them abroad.

6. Political Corruption: Causal Link – Demonstration and Explanation for PCD in Africa:

Authoritative sources have associated poverty in Africa to corruption. Sachs and his collaborators at the Millennium Project, for example argue on the implication of corruption on poverty in Africa. They contend that the quality of governance is proportionate to the amount of money available for it, and adjusting a number of corruption-related indicators for poverty, they found that African governance is not bad by international standards, pointing out that poor countries cannot afford the corruption controls available in better-resourced ones (Sachs et al, 2004: 3-4). The significance of their argument to this paper is that there are certainly 'corruption-related indicators of poverty' in Africa that need to be adjusted (these include embezzlement, political patronage, money laundering, bribery, invoicing and over estimation of project and contract); this things impacts on governance negatively in Africa. Just as UN Secretary General Kofi Annan notes,

'Corruption is found in all countries – big and small, rich and poor – but it is in the developing world that its effects are most destructive. Corruption hurts the poor disproportionately by diverting funds intended for development, undermining a Government's ability to provide basic services, feeding inequality.... Corruption is a key element in economic under-performance and a major obstacle to poverty alleviation and development (in UNODC, 2005: 92).

Wentling (2002: 5) castigates corrupt, oppressive leaders in Africa, and suggests that what is most needed is a consistent and aggressive "tough love" diplomacy that refuses to deal with leaders who have fortunes stashed away in foreign bank accounts, and steps up support for legitimate, non-violent opposition groups, while most African states sink deeper into an almost irreversible morass of poverty and chaos.

Currently, there are further corruption charges against five African leaders and their families who used embezzled funds to buy homes in France: These are Gabon's President Omar Bongo, Republic of Congo President Denis Sassou Nguesso, Burkina Faso President Blaise Compaore, President Teodoro Obiang Ngeuma of Equatorial Guinea and Angolan President Jose Eduardo dos Santos (The International Herald Tribune, 2008). The United Nations Office on Drug and Crime notes that siphoning off funds by wealthy elites is doubly problematic in Africa, as much of this graft is immediately invested outside the continent, and that about 40% of all African private portfolios are held overseas, and this share is likely to be even greater when the funds have been obtained through corruption. (UNODC, 2005: 91). It is therefore because of the devastating level of political corruption in Africa that Jeremy Pope, one of the founders of Transparency International, labelled the African model as 'lootocracy, you don't find it anywhere in the world' (in Wrong, 2005).

There is a contrary view that African poverty is due to poor economic growth; Marke (2007: 2) argues that in much of Africa, very little economic growth has occurred and some countries are even poorer today than they were thirty years ago. Also according to J. Bradford Delong of California, Berkeley (in Marke, Ibid), 'the twentieth century has been the century of increasing wealth in the industrialised economies: in material and standard of living, but for the majority of Africans, it has been an era of negative growth...'

However, studies have shown that corruption is the major factor negating 'growth' in Africa. The negative impact of political corruption on investment predominantly affects economic growth. The IMF for example (in Mauro 2004) notes, 'there is a close association between corruption and slow growth, as well as between corruption and political instability'. Though the IMF just points out the association, however, the World Bank (in UNODC, 2005: 81) agrees that by distorting the rule of law and weakening the institutional foundation of economic growth, corruption is the single greatest obstacle to economic and social development; noting that the harmful effects of corruption are especially severe on the poor, who are hardest hit by economic decline, and are the most reliant on the provision of basic needs and public services.

Political corruption thus has a deleterious effect on poverty or aggravates the existing state of poverty in most African states. And it is likely that poverty caused by agents particularly political leaders entrusted with the nation's wealth could be reacted against by the poor masses in a way of engaging in conflicts as a means of addressing their plights, because of their unmet human basic needs. These conflicts have many consequences since the people commit other atrocities to vent their aggression. As the World Bank argues in its October 2004 paper 'Post-Conflict Peace Building in Africa', conflict tears the fabric of the society, with the overall effect of lowering ethical standard and creating an environment that breeds crime (World Bank, 2004). This does not augur well for meaningful development.

Yet, another counter argument according to Nwankwo (1995: 218-221) is that in addition to the problems of hunger and poverty created by what he calls 'irresponsible leadership' (Ibid: 219); there are also the problems of poverty and want engendered by structural dislocation and mass dislocation of people. With millions daily losing their means of livelihood, and their lands being increasingly unproductive due to elementary forces, destitution sets in, with attendant malnutrition, disease and death. Material impoverishment and spiritual alienation of Africa's millions add to the problem of slum and shanty dwelling, and the evolution of sub-culture of crime, violence, civil unrest, prostitution and other forms of social and moral depravity. This in turn reduces the percentage of the active population engaging in productive and creative ventures, compounding the problems of development (Ibid).

However strong Nwankwo's contention might be, the true situation is that all socio-economic dislocations and other elementary forces, which he claims causes poverty, leading to instability and poor development, is possible in countries that lack political development (and this study will show that political development is incomplete in Africa unless there is an 'absence of political corruption'). Just as Sen (1999: 61-63) argues, famine, drought and related disasters are not allowed to occur in developed and democratic polities because people have established mechanisms to compel governments to address their needs and pressing problems. And Daniel Kaufman, the World Bank Institute's global governance director (in CIOB, 2004) notes that World Bank research has revealed a 400 per cent governance dividend where there was good governance and corruption was under control. Countries that improve on corruption could expect in the long run a four-fold average increase in incomes per capita. Thus a country with income per capita US \$2,000 could expect to attain \$8,000 in the long run by making strides in controlling corruption. Similarly, such a country could expect on average a 75 per cent reduction in child mortality and improvement in its poverty stance.

The above contention needs to be substantiated with more evidence; Japan and Hong Kong for example have a weak climate, coupled with negligible natural resources. Yet these two countries (like other New Industrialised Countries 'NIC') conquered their environment because their developed political sectors invested in technology (Marke, 2007: 3). Similarly, Singapore, with a population of 4.5 million (July 2007), which became a British colony in 1867 is neither poor, nor is wide-spread conflict common there, and it is very developed and business operates in a corrupt-free environment, since the leaders are not corrupt and they were able to meet the basic needs of their citizens. They all have a low level of corruption (with impressive ratings of 7.6, 8.3 and 9.4 respectively, see CPI Transparency International, 2006). In Sierra Leone (which became a British colony in 1808), with a population of 6.1 million (July 2007 estimate) is endowed with substantial mineral, fishery and agricultural resources, but is extremely poor like many Africa countries and corruption, particularly political corruption is endemic in the country as in many countries in the continent, and the basic need of the citizens are not met (ibid, see also Appendix A).

The argument that African poverty has much to do with a population is also pertinent. For example, the size of the population between 1980 and 2002 in Sub-Saharan Africa grew from 383 to 689 million, suggesting an increase of 80% (RCA, 2005: 112), while growth rate declined from US \$575 in 1980 to \$524 in 2005 (Schaefer, 2005). Though the African population undoubtedly is increasing and impacting on Africa, however, when it is appreciated that African population is still young (the youngest among all the continents), 44% of Africa's population is under 15 years old, compared with only 34% in South Asia and 28% in East Asia (RCA, Ibid), then it stands to reason that this young population should be active and therefore an asset to Africa. A possible explanation is that majority of African leaders have exploited its youth, the national wealth, which the political leaders could have used in empowering the youths, particularly the investment which creates and safeguards sustainable jobs for the youths (that will enable them meet their basic needs) is either out-rightly embezzled or corruptly stashed away in foreign banks by these leaders, thereby leaving the youths to idle away in hunger.

Historically, when youths are not engaged in meaningful work and are lacking the basic necessities, they bring attention to their plight by engaging in destructive behaviour (Marke, 2007: 7), this underscores the importance of Human Needs Theory. This view point substantiates the argument of this paper that when youths cannot bear their poverty (particularly lack of basic needs), caused or worsened by political corruption of most African leaders (who appear to be above the law or the law themselves) anymore, they react by engaging in conflict, with its negative effects, which stunt development. The case of youths in the Niger-Delta conflict in Nigeria is a good example, the youths committed lots of atrocities, including the kidnapping of UK expatriates (Onyeiwu, 2004: 6). This is also the reason why prisoners in Africa are mostly the poor who did little or nothing, just as Wentling (2002: 4) critically argues:

As long as political elites and the wealthy can do as they please without fearing any kind of legal sanctions, the huge and growing gap between the great mass of people who have little and the small percentage of the population who possess much will grow. Corruption (particularly by leaders) is endemic throughout the continent and at virtually all levels of society. In fact, sometimes Africans who defraud the government or private firms to enhance the status of their family are looked upon as role models than criminals. Justice is very much lacking: small-time thieves who steal food for themselves or their families are severely punished while big government officials who embezzle millions from the state treasury and live grossly opulent lives are applauded.

The CIOB (2004) points out that the embezzlement of public funds by unscrupulous and corrupt leaders of developing countries leads to poverty, high debts and other socio-economic problems that impact negatively on development. Irobi (2005: 1) states that the countries of Sub-Saharan Africa, including Sierra Leone, DRC, Ivory Coast, Liberia and so many others are a volatile mix of insecurity, instability, corrupt political institutions and poverty. However, the argument so far suggests that it is the corrupt political institutions, particularly political corruption that causes or worsens poverty (the lack of basic needs) that leads to instability in Africa.

As explained, my argument is that political corruption causes or worsens the state of poverty, which leads to conflicts, with the negative impacts that hinder development.

In Table 1 (below), Kenya is employed for illustration, this Table shows that in Kenya, by the time President Arap Moi entered into power, poverty in that country was at 27%, Gini Coefficient of 0.40 (Kayizzi-Mugwerwa, 2001: 6) conflict was low, and GDP was between 3%-4.2% (Okafor, 2004: 67) however, during his tenure (1978-2002), Arap Moi embezzled the sum of \$1 billion, official figure (Azami, 2005). Within this period, particularly in 1991/92, poverty increased to 30%, Gini rose to 0.49% (Kayizzi-Mugwerwa, 2001) conflict was severe within this period – in 1991/92 and July 1997) (Wayande, 1997: 6) and development in Kenya was stunted, since her GDP came down to 2.1% in 1991, 0.5% in 1992 and 0.2% in 1993 (Okafor, 2004).

It is interesting to note too, that Kenya transited from the corrupt low-achievement leadership of Arap Moi to Mr. Mwai Kibaki in 2003, yet the situation has not changed (ibid). While President Kibaki is investigating the embezzlement of \$1 billion by his predecessor, credible allegations of political corruption under the new regime are currently on board. For example, in an open revelation and without mincing words, the British High Commissioner to Kenya has stated that 'the new corruption entered into by this government may be worth around \$188 million (Azami, 2005). This is the case with Nigeria, and was particularly so during the regimes of Ibrahim Babangida and Sani Abacha. It was also the in apartheid South Africa, particularly during the tenures of P. Botha and F. W. De Klerk. Another case is Zaire, during the regime of S. Mobutu. These are in addition to the African countries (Angola, Equatorial Guinea, Liberia, Morocco and Togo) as demonstrated in the table (see Appendix A). Recent studies support this, for example the studies on the Gambia, Mozambique and Ghana in 2004, suggest that corruption allows the rich, particularly political leaders in Africa to avoid paying taxes (UNODC, 2005: 91). This fuels further income inequality (widening the gap between the rich and the poor), which is highly associated with conflict and has a negative effect on growth and development.

However, a comparative assessment with some countries, for example Botswana (the continent's model of stability and good governance), Mauritius and South Africa (post apartheid), suggests that in these countries with low records of political corruption (these countries scored above 4.2 global average in the most recent '2006' Transparency International – corruption perception index, 2006), their poverty level is low, for example, Botswana has just 23.5% population of those on poverty below \$1 a day in 1990-2004 (UNDP Human Development Index, 2006) and wide-spread conflicts are uncommon (as illustrated in Appendix B). Furthermore, there is viable development, since Mauritius is in the High Human Development, Botswana and South Africa are impressive in the Medium Human Development, for example, they have 100, 95 and 88 respectively on population with sustainable access to an improved water sources, comparative to other African countries, particularly the Sub-Saharan ones (UNDP Human Development Report, 2006).

In Table 2 (below) The entire Africa and Sub-Sahara were also used for illustration, this Table suggests that the entire Africa and Sub-Sahara, since the past three decades or more (particularly mid 80s and 1990s) statistics reveal that political leaders have stolen about \$33 billion; this has caused or worsened poverty, making half of the Sub-Sahara's live on less than 65 US cent a day, leading to over 32 conflicts, which has resulted in a rise in crime rates to 8%, 6% and

4% for burglary, assault and robbery, respectively. This has been accompanied by a decline of 0.8% in development in Sub-Saharan Africa (UNODC, 2005: 2).

7. Summaries and conclusion

In summation, my argument is that corruption, particularly political corruption directly undermines democracy and governance by destroying the trust relationship between the people and the state. An indispensable obligation of the state is to provide the basic needs of its people and also to ensure the safety of its citizens. When the state fails to fulfil this obligation, or provides for some groups, but not for others, or worse when the leaders are corrupt, the people effectively reclaim their right to use force (conflict) in the resolution of disputes, often with disastrous consequences, such as a rise in crime and stunted development. Thus, my argument is that 'Political Corruption (POL C) causes or worsens Poverty (POV), which leads to an increase in Conflict (C), which in turn leads to the stunting of Development (DVP). That is $POL C \rightarrow POV \rightarrow C \rightarrow DVP$. In conclusion, though, there are no doubt, additional explanatory variables and theories for the relationship between poverty, peace and development in Africa, as discussed; it is my argument that political corruption is the major and most persuasive causal factor and the human needs theory most relevant for this paper.

Bibliography

- African Forum and Network on Debt and Development (2007), *Nigeria: Foreign Debts, Stolen Wealth, IFS and The West*, A case study': AFRODAD.
- Atojoko, S. (2003), 'Rape of Nation' Newswatch. Feb. 24, 2003.
- Azami, R. (2005), 'Profligacy, corruption and debt, Daily Times (Pakistan) February, 10, 2005, at <http://www.odiousdebts.org/odiousdebts/index.cfm?content&ContentID=12387> (05/02/07).
- Burton J. (1997), 'Violence Experienced: The Source of Conflict Violence and Crime and Their Prevention', Manchester University Press: New York.
- Campbell, D (2004), 'Havens that have become a tax on the world's poor', Guardian: UK, 24 September, 2004, available at <http://www.odiousdebts.org/odious/index.cfm?DSP> (05/02/07).
- Chartered Institute of Building (2004), *World Bank finds corruption is costing billions in lost development power*, CIOB September 29, 2004, at <http://www.odiousdebts.org/odiousdebts/index.cfm...ID=11519> (05/02/07).
- Collier, P. (1997), *The Role of the State in Economic Development: Cross Regional Experience*: Plenary paper presented at the AERC Research Workshop, 6-11 December; Harare, Zimbabwe.
- Commission for Africa (2005), *Our Common Interest, The Report of the Commission for Africa: CA*.
- Dorman, R. (1993), 'Africa's Despots and Their Lots', Tell October 13, 1993.
- Egbo, S. (2002), *Nigeria and the world: A treatise on foreign policy*, John Jacob's Classic Publishers Ltd: Enugu.
- Ehrlich, I. (1973), Participation in Illegitimate Activities: A Theoretical and Empirical Investigation. *Journal of Political Economy*, May, 81:3, 521-65.
- Erikson, M. and Wallenstein, P. (2004), 'Armed Conflicts, 1989-2003: *Journal of Peace Research*, Vol. 41, No. 5, 2004 .625-636.
- Fapohunda, O. (2002), 'from OAU to AU: The Challenges to Human Rights, Vanguard: Lagos, 2nd Aug.
- Glazer, N. and Moynihan, D. (1975), eds. 'Ethnicity and Experience', Cambridge, Mass: Harvard University Press: Atlanta Georgia.
- Green, R. and Seidman, A. (1968), 'Unity or Poverty?' The Economies of Pan Africanism Hamandsworth: Penguin.
- Gurr, T. (1970), *Why Men Rebel*: Princeton.
- Hoffman M. (2004), *Surveys says corruption rampant across globe, Business Report* (South Africa) October 21, 04, at <http://www.odiousdebts.org/odiousdebts/index.cfm...ID=11693> (05/02/07).
- International Herald Tribune (2008), *French prosecutors probe embezzlement accusations against African leaders* at <http://www.iht.com/bin/print.php?id=6211623> (12/01/08).
- Irobi, G. (2005), 'Ethnic Conflict Management in Africa: A comparative Case Study of Nigeria and South Africa', Conflict Research Consortium: University of Colorado.
- Kayizzi-Mugerwa, S. (2001), *Globalisation, Growth and Income Inequality: The African Experience*; Working Paper No. 186 (Formally Technical Paper No. 186); Research Programme on: Empowering People to Meet the Challenges of Globalisation: OECD Development Centre.
- Marke, D. (2007), 'Will Africa Ever Be Able To Replicate Successful Economies? December 16, 2007.

- Mauro, P. (2004), *The Persistence of Corruption and Slow Economic Growth*, IMF staff papers Vol. 51, No1, 2004.
- Mohammed, N. (1999), *Civil Wars and Military Expenditure*: A Note prepared for presentation at the World Bank's Development Economic Research Group (DECRG) launch conference on 'Civil Conflicts, Crime and Violence', World Bank, Washington, D.C; 22-23 Feb; 1999.
- Nathan, L. (2003), *Crisis Resolution and Conflict Management in Africa*; Centre for Conflict Resolution, University of Cape Town: South Africa.
- Nnoli, O. (1980), *Ethnic Politics in Nigeria*, Fourth Dimension Publishers: Enugu
- Nnoli, O. (1981) eds., *'Path to Nigeria Development'*, Zed Press: California.
- Nwankwo, A. (1995), *The African Possibility in Global Power Struggle*, Fourth Dimension: Enugu.
- Okafor, C. (2004), *Neo-Democracy and Poverty Management in Africa*: Mercury Bright Press: Awka, Nigeria.
- Okanya, O. (1996), *Political Thoughts*, an Unpublished Mimeo, Department of political Science, Enugu State University: Nigeria.
- Omitoogun, W. (2001), Military Expenditure and Conflict in Africa: *DPMN Bulletin*, Vol. VIII, No. 1, July.
- Onyeiwu, S. (2004), *On the Economic Determinants of Violent Conflict in Africa: Preliminary Evidence From Nigeria*, Helsinki: Finland.
- Oputa, L.. (1994), 'Who is Who Among the Poor', The Guardian on Sunday, April 17, 1994.
- Sachs, JD., McArthur, JW., Schmidt, G., Kruk, M., Bahador, C., Faye, M., & McCord, G. (2004), *Ending Africa's Poverty Trap*, Mimeo: available at www.unmillenniumproject.org, (17/2/07).
- Salih, M. (1999), *Governance, Information and the Public Sphere*: UN Economic and Social Council; Economic Commission for Africa, Third Meeting of the Committee on Development Information (CODI): Addis Ababa: Ethiopia, 10-17 May 2003.
- Sandbrook, R. (1982), *The Politics of Basic Needs*, Heinemann: London.
- Schaefer, B. (2005), *How the Scope of Government shapes the Wealth of Nation*, Heritage Lectures: No 925 Delivered December 1, 2005.
- Seidman, A. Seidman, R and Mbana, P. (2006), *'African Challenges': Using Law for Good Governance and Development*, Africa World Press: USA.
- Sen, A. (1999), *Development as freedom*, Alfred A. Knopf: New York.
- Transparency International (2006), Corruption Perception Index: TI.
- UNDP (2006), *Human Development Report*, United Nations Development Programme Oxford University Press: New York.
- United Nations Office on Drug and Crime (2005), *Crime and development in Africa* (2005), UNODC: New York.
- Vuuren, H. (2006), *Apartheid Grand Corruption, Assessing the Scale of Crimes of Profit in South Africa from 1970 to 1994*; a report prepared by civil society at the request of the Second National Anti-Corruption Summit, May, 2006.Center for Conflict Studies: Cape Town.
- Wanyande, P. (1997), *State Driven Conflict in the Greater Horn of Africa*, Revised Paper Presented at the USAID Organized workshop on Conflict in the Great Horn of Africa May 21-23, Methodist House: Nairobi.
- Wentling, M. (2002), *'My 30 Years in Africa: Still Searching for Answers'*, American Foreign Service Association (AFSA): 2101 E Street NW, Washington, DC 20037.
- Wisner, B. (1988), *Power and Need in Africa; Basic Human Needs and Development Policies*, Earthscan Publication Ltd: London.
- World Bank (2004), *'Post-Conflict Peace Building in Africa: The Challenge of Socio-Economic Recovery and Development'*; Africa Regional Working Paper Series No. 73, October 2004.
- World Bank (2005), *Population data from Word Bank*, World Development Indicators 2005, at www.worldbank.org/data/onlinebases/onlinebases.html (12/02/06).
- World Bank (2006), *Africa Development Indicator*: Washington D.C.
- Wrong, M. (2005), *When the Money goes west*, New Statesman March 14, 2005.

Table 1. Kenya is employed for Illustration

→ Data before corrupt regime ←			→ Data during and after corrupt regime ←			
Poverty (national income)	Conflict	Devp. (GDP)	Country, corrupt regime(s) and amount embezzled	Poverty (national income)	Conflict	Devp. (GDP)
Poverty was at 27% and Gini at 0.40 by 1982	Less internal conflict as 1981	GDP in 1979 4.2%	Kenya: A. Moi (1978-02) \$1b	Poverty increased to 30%, and Gini increased to 0.49 in 1991	Conflict rose between 1991/92	Aid embargo for lack of governance in early 90s GDP in 1991, 2.1% and 1992, 0.5%

Sources: For Poverty see Kayyizi-Mugerawa (2001: 6), for Development see Okafor (2004: 67), for corrupt embezzlement, see Azami (2005: 2), for Conflict see Wayande (1997:6), also see Appendix A.

This Table illustration with Kenya demonstrates that political corruption causes or worsens the state of poverty, which leads to conflicts, with the negative impacts that hinder development.

Table 2. Illustration with the entire Africa and Sub-Sahara

Entire Africa and Sub-Sahara within the last three decades			
Corruption: as at 1999 African leaders had stowed \$20bn in Swiss bank account, and total of \$33bn out of Africa.	Poverty: as 2002, half of Sub-Saharan Africa lives on less than the equivalent of 65 US cents per day.	Conflict: of 116 conflicts recorded by UNDP since the end of the Cold War (1989), only seven were between states – 109 were internal, and Africa had more than 32 of these between 1989-03.	Development: GDP per capita declined in Sub-Saharan Africa by 0.8% per annum over the 1975-2002 periods.

Sources: On Corruption, see Wrong (2005) and Okafor (Ibid), on see Poverty UNODC (2005: 2), on Conflict, see Erikson and Wallenstein (2004: 625-636) and on Development, see UNODC (2005: 2). See also Appendixes A and B.

Table 3. establishes that in the entire Africa and Sub-Sahara within the last three decades political corruption worsens the state of poverty, which leads to more conflict and all this has retarded development in the Sub-Saharan Africa.

APPENDIXES

Appendix A: Political Corruption: Causal Link – Demonstration and Explanation for Poverty, Conflict and Development in Africa:

→ Data before corrupt government ←			→ Data during and after corrupt government ←			
Poverty (national income)	Peace (conflict and crime)	Devp. (GDP)	Country, corrupt regime(s) and amount embezzled	Poverty (national income)	Peace (conflict and crime)	Devp. (GDP)
NA	(a) Conflict and crime high	(b) By 1980 861 per capita	(c) Angola: J. Santos (1979-cont.) \$4b	(d) Within this period 3.7m children malnourished	(a) Conflict and crime intensify and citizens displaced	(b) 1990 804, and 1998 651 per capita
(e) Impressive	(a) Absence of conflict	(b) By 1980 1,077	Botswana (no record of	e) impressive	(a) Peace continue to	(b) 1990 2,222 1999 2,612

	and crime	p.capita	embezzlement)		flourish	
--	--	--	(j) Equatorial Guinea: T. Obiag (1979-cont.) \$1.2b	--	(a) Conflict and crime since 2000-01	--
(f) Poverty was at 27% and Gini at 0.40 by 1982	(g) Less internal conflict and crime as at 1981 until next decade	(f) GDP in 1979 4.2%	(c/h) Kenya: A. Moi (1978-02) \$1b	(f) (g) Poverty increased to 30%, and Gini increased to 0.49 in 1991	(s) Conflict and crime rose between 1991/92	(f) Aid embargo for lack of governance in early 90s GDP in 1991, 2.1%, and 1992, 0.5% and 0.2% in 1993
--	(a) Conflict and crime low	(b) 1980 444 p.capita	(i) Liberia: S. Doe (1986-90) \$1.5b	--	(a) Conflict and crime 1989-03	(a) 1990 203, '99 153 p.capita
(e) impressive	(a) Absence of conflict and crime	(b) By 1980 1,570 per capita	Mauritius (no record of embezzlement)	(e) impressive	(a) Peace continue to reign	(b) 1990 2,532 1999 3,665 per capita
--	(a) Conflict and crime less before 1975	(b) Annual growth 1980-89 (2.0%)	(c) Morocco: King Mohammed VI (1999-?) lavish \$268m yearly (18 times more than Queen Elizabeth)	(c) Since 1999 a country where a fifth (5 th) of the population has to survive on less than \$1 per day	(a) Conflict and crime 1975-89	(b) Annual growth 1990-99 (0.8%)
(l/n) By 1985 46% and Gini was 0.37	(m) Conflict less during Buhari/ and Idiagbon regime	(g) 1980 21% growth	(k/l) Nigeria: I. Babangida (1983-92) \$11b and S. Abacha (1993-98) \$5b	(n) 1998 68% and as at 1992 Gini was up to 0.416	(m) (t) Conflict since 1985; crime increased e.g. murder 838 in 1998 to 928 in 1999	(g) 1985 9%, 1990 15% growth
NA	(o) Between 1948 – 60s conflict and crime were not severe	(g) 1965 (22%), 1970 (23%) growth	(p) South Africa: H. Verwoerd (1958-66) \$1.7b; P. Botha (1978-89) \$4b and F.W. De-Klerk (1989-94) \$2b	(q/r) 70s and 80s around 50% and as at 2000 34%	(o) (u) Conflict intense between 1970-94; crime increased e.g. murder 10,000 to 11,000 by 1990	(g) 1975 (25%), 1980 (23%), 1985 (15%), 1990 (12%) growth
--	(a) Conflict	--	(h) Togo: G Eyadema	--	(a) Conflict and crime	--

	and crime less		(1967-05) \$3b		high in 1991	
--	(a) Conflict less	--	(k) Zaire: S. Mobutu (1965-97) \$5b	--	(a) Conflict and crime intense 1996-01	(g) 1980 251, 1990 203, and 1998 101 p.c
Entire Africa and Sub-Sahara within the last three decades						
Corruption: as at 1999 African leaders had stowed \$20bn in Swiss bank account, and total of \$33bn out of Africa.	Poverty: as 2002, half of Sub-Saharan Africa lives on less than the equivalent of 65 US cents per day.	Conflict: of 116 conflicts recorded by UNDP since the end of the Cold War (1989), only seven were between states – 109 were internal, and Africa had more than 32 of these between 1989-03.	Crime: African victimisation rates since 80s were 8% for burglary, 6% for assault and 4% for robbery. Together these major crime types, Africa have the highest total figure.	Development: GDP per capita declined in Sub-Saharan Africa by 0.8% per annum over the 1975-2002 periods.		

Sources: (a) Uppsala Conflict Data Programme (2003) (b) African Development Indicators (2006),(C) Azami (2005), *Profligacy, corruption and debt*, Daily Times (Pakistan) February 10, p.2, also available at <http://www.odiousdebts.org> (05/02/07) (d) Ccommission for Africa (2005), *Our Common Interest, The Report of the Commission for Africa* (e) UNDP, Human Development Report (2006), *United Nations Development Programme* Oxford University Press: New York (f) Okafor, C (2004), *Neo-Democracy and Poverty Management in Africa*, Mercury Bright Press: Awka, Nigeria p.67 (g) Kayyizi-Mugerwa, S (2001), op cit (h)Wrong, Michela (2005), *When the Money goes west*, New Statesman March 14, 2005, (i)encyclopadea.com,

(j)AfrolNewsavailableat [http://www.uneca.org/srdc/ca/news/End%20March/\(05/02/07\)](http://www.uneca.org/srdc/ca/news/End%20March/(05/02/07)) (k) The Chartered Institute of Building (2004), *World Bank finds corruption is costing billions in lost development power*, CIOB September 29 (l) AFRODAD (2007) op cit (m) Onyeiwu, Steve (2004), *On the Economic Determinants of Violent Conflict in Africa; Preliminary Evidence From Nigeria*, Paper Prepared for Presentation at WIDER's Conference on Making Peace, 4-5 June, Helsinki: Finland. (n) Oxfam (2003), 'Social Development and Poverty in Nigeria', available at http://www.oxfam.org.uk/what_we_do/resources/downloads/wp-nigeria/wp-nigeria_socdev.pdf (12/8/06) (o) Regional Survey of the World, Africa and Sub Sahara (2002), Europa publication: London. (p) Vuuren H (2006), op cit (q) May, Julian (1998), *Poverty and Inequality in South Africa* report prepared for the office of the Executive Deputy President and Inter-Ministerial Committee for Poverty and Inequality, Pretoria S/A. (r) Bohart, H. and R. Kanbur (2006), eds., *Poverty and Policy in Post Apartheid South Africa*, HSRC Press: Pretoria. (s) Wayande P. (1997), *State Driven Conflict in the Greater Horn of Africa*, paper presented at the USID Organized workshop on Conflict in the Greater Horn of Africa, Methodist Guest House: Nairobi, (t) Trends in Crime (2002). (u) Robert Winslow (2002), *A Comparative Criminology Tour of the World*, South Africa: San Diego State University.

For Africa and Sub-Sahara – on Corruption Wrong (Ibid) and Okafor (Ibid), on Poverty UNODC (2005: 2), on Conflict Erikson and Wallenstein (2004: 625-636) and on Development UNODC (2005: 2).

Appendix B: Comparative studies of conflicts in selected African countries (1960-2007)

Countries	Internal/external	Communal aggression	Civil strife, riots and violent demonstrations	Political violence
Democratic Republic of Congo	Internal with external participation	Very high	Low	High
Mauritius	Not reported	Normal	Normal	Normal
Egypt	Internal	Average	Average	High
Nigeria	Against Cameroon	Very high	Very high	Very high

Rwanda	Internal with foreign involvement	Very high	Low	High
Sierra Leone	Internal with foreign involvement	Very high	High	High
South Africa	Not reported	Very high	Very high	Very high
Ethiopia	Internal	High	Average	High
Botswana	Not reported	Normal	Very low	low

Sources: Uppsala Conflict Data Programme (2003 in UNODC, p.17), Ikejiaku, B. (2008), The relationship between poverty, peace and development in Africa, political corruption emphasised 1960-2007: case studies of Nigeria and South Africa, unpublished (submitted) PhD Thesis, School of Politics, International Relations and Philosophy, Keele University, United Kingdom. Note: 'not reported' means absence of conflict or data unavailable; 'normal' means absence of conflict reported, while very low, low, average, high and very high are rated based on number of occurrence, intensity and duration of the conflict.



Harmonious Sports: the Ideal Pattern of the Sustainable Development for the Competitive Sports

Te Bu

Graduate College, Beijing University of Physical Education

Beijing 100084, China

E-mail: buteagu@sina.com

Abstract

In the paper the authors think that the competitive sports of China also face many challenges such as much more investments and low benefits, deficient talents and prominent structured conflict. Therefore, the sustainable development of the competitive sports means to adapt the development demand of the social and economic cultures and promote the comprehensive, harmonious and sustainable developments between the competitive sports and human according to the people-oriented principle. First, the humanized development of the competitive sports should be emphasized. Second, the comprehensively harmonious development of the competitive development should be emphasized. Third, the permanent durative development of the competitive sports should be more emphasized. Fourth, the diversity development of the competitive sports should be more emphasized. The new whole-nation system of the competitive sports in the harmonious society is not only the “sports mechanism with Chinese characteristics which is dominated by the government, governed by the society and controlled by the market, and combines the market measure with governmental investment”, but also the modern management mechanism with small investment and more outputs, high efficiency and low costs. We must quickly establish the talent cultivation system of the competitive sports in the market dominated by the government. To deal with the relationship between the scale and the benefit for the competitive sports and conform to the projects allocations of competitive sports, only we can reasonable arrange and allocate resources, and adjust measures to develop the sports events of the competitive sports according to the characters and conditions of various regions, and we can ensure the sustainable, stable and healthy development of Chinese competitive sports.

Keywords: Harmonious sports, People-oriented, System innovation, Scientific selection, Reasonable allocation

In the Beijing Summer Olympics of 2008, the competitive sports of China have created resplendent achievements, overwrote the history of the Olympics, and fully exhibited the strength of Chinese competitive sports. However, we must clearly realize that there are many challenges for Chinese competitive sports, such as much more investments and low benefits, deficient talents and prominent structured conflict. So to keep the sustainable development, the competitive sports be reformed and innovated, and follow the harmonious and sustainable development road.

1. Harmonious sports: the direction of the sustainable development for the competitive sports

The Chinese academia has discussed and studied the definition of the sustainable development of the competitive sports and the development road. But “certain blundering emotions” exist in the present researches (Pan, 2002), and the systematic and profound researches about the character and meaning of the sustainable development of the competitive sports, the physical sustainable development strategy and the physical sustainable development index system are still deficient. As we all know, the competitive sports are the special cultural phenomena in the society, and they are the social practical activities which take human as the rebuilding objects. Its sustainable development is not only same but different with the sustainable development of the social and economic cultures.

We think that the sustainable development of the competitive sports means to adapt the development demand of the social and economic cultures and promote the comprehensive, harmonious and sustainable developments between the competitive sports and human according to the people-oriented principle. To realize the sustainable development, the competitive sports must adapt and harmonize with the developments of the economy and the culture, consciously cater for the tendency of the social history, and actively follow the tide of the modern times. The development of the competitive sports must adapt the support of the economic and social development, the capability of the cultural and educational developments and the carry ability of the ecological environment system, which can make the competitive sports comprehensively, harmoniously and sustainably develop. And that is the deep relationship between the

competitive sports with the developments of the economy and the society, the developments of the culture and the education, and the development of the ecological environment, and its core is the multiple relationships between the competitive sports and human. The deep essential of the sustainable developments of the competitive sports, the social sports and school sports is the ordered development, the humanized cultivation and the harmonious development of the sport talents and it is the problem about the effective integration and the ecological development of the sports resources. The sustainable development of the competitive sports means the harmonious and balanced development of the interior factors and resources of the competitive sports. Whether for the harmony among the competitive sports and the social sports or the school sports, or for the harmonious development of the competitive sports, the essential means the harmonious development of the multiple values of the competitive sports such as competition, amusement, education, representation and leisure, and the harmonious development of the competitive sports and human. Therefore, we think the sustainable development of the competitive sports means the harmonious development of the competitive sports with the society, and the harmonious development between the competitive sports with human. The sustainably developmental competitive sports are the deep regression of the sports essential, the time appearance of the harmonious sports and the coruscation of the humanized sports (Bu, 2007). So the sustainable development of the competitive sports possesses following notable characters.

First, the humanized development of the competitive sports should be emphasized. The aim of development should be the human development of body and mind and continually fulfill the human demand for the comprehensive development, not the project and technology even the gold medal. Second, the comprehensively harmonious development of the competitive development should be emphasized. The enthusiasm of the development main body should be mobilized, and the interior association and effective integration of many development factors such as competitive sports, social sports and school sports should be strengthened, and the harmony of the competitive sports and the social developments should be realized. Third, the permanent durative development of the competitive sports should be more emphasized. The development of the competitive sports talents and the increase of the competition events should adapt the carry ability of the social resource and the human, and the present people should benefit offspring and establish long-effective mechanism. Fourth, the diversity development of the competitive sports should be more emphasized. The development of the competitive sports should transform from the single mode of gold medal to the development mode with multiple values such as amusement, education, leisure, economy and representation. In a word, the competitive sports of the sustainable development are “to achieve the integrated dynamic harmony including human and the nature, human and human, human and themselves by the ideas and measures of the comprehensive harmony of the sports” (Wang, 1997).

2. People oriented: the essential and core of the sustainable development for the competitive sports

The people-oriented competitive sports mean that the sport must promote the perfection of the human and sever for the development of the human. First, the intention of the competitive sports is human. The training, game, gold medal and name of the competitive sports are measures not intention, and the intention is the development of the human. Second, the development of the competitive sports should fully consider the carry ability of the human. The practices have proved that the sports include the competitive sports actually can strengthen human constitution and preserve human health. But undeniably, the sports especially for the competitive sports are a handful of double-edged sword, and the sports will probably bring sports hurts. So the development of the competitive sports must accord with the rule of the human themselves and harmonize with the carry ability of the human, or else, the people-oriented intention can not be realized. The aim of the competitive sports is faster, higher and stronger. However, how to define that? Can the competitive sports exceed the limit? Is human energy bottomless and inexhaustible? In the new century, Rogge put forward that the aim of the competitive sports development was “cleaner, more humanism and more united”, which endowed the “faster, higher and stronger” with new meanings and embodied the “people-oriented” development view of the competitive sports. Third, the competitive sports should fully embody the humanism and individualization. Sports especially for the competitive sports are the sports to show the individuality. Without the development of the individuality, there is no the comprehensive development of the human. The people-oriented development is to stand out the characters such as the whole nation, the foundation, the personality and the difference of the competitive sports and realize the free and comprehensive development of the human. To realize the “people-oriented” development objective, the competitive sports should complete following aspects.

First, the competitive sports should walk out the “gold medal orientated” mistake and realize the “people-oriented” multiple values function. The development course of the competitive sports is actual the process from the single value function to the multiple values function. However, for a long term after China was founded, because of the influences of the international climate and the domestic environment then, the dominant value view of China emphasized the importance of the political behaviors and political orders, and the political demand became the main direction of various works in China, and the competitive sports also took the “country-oriented” as the only valuable tropism and took the service for the national politics as the highest aim. So, the political function winning glory for the motherland was notably emphasized, and other functions of the competitive sports were gradually forgotten even abandoned, and the

situation of the single value function formed. With the deepening of the economic system reform in China, especially under the time background to establish the socialism harmonious society, the competitive sports are experiencing two important transformations, i.e. “from the grouped political demand to the human essential demand, and from the compulsory material gain demand of the society to the active demand of the individual healthy and happy living (Hu, 2000)”. Human concern degree about the political function of the competitive sports is gradually fading, and the economic function, the education function, especially for the leisure and amusement function of the competitive sports are more and more obvious, and the time change from the “gold medal oriented” to the “people-oriented” is gradually being realized. Therefore, when the development strategy of the competitive sports of China is confirmed, we are required to exactly grasp the essential and various social value functions of the competitive sports from many layers such as driving and popularizing the competitive sports, developing the economic function and enriching the education, amusement, training and leisure functions for the cultural and entertainment activities, abandon past “gold medal oriented” single competitive sports function concept, ensure the sustainable development of Chinese competitive sports along the scientific development view, and realize the aim of the real “people-oriented” and harmonious development when we emphasize obtaining excellent sports achievements and gold medals.

Second, the competitive sports should largely advocate the humanism. The biggest obstacle of the sustainable development of the competitive sports is the deficiency of the humanism. When emphasizing the political demand, Chinese competitive sports had ignored and oppressed the individuals and personality for a long time. When the sports concepts such as personality, individualization and living have led the tide of the global sports development, we are hard to avoid feeling confusion and attaching the old sports theory. In the new century, especially in the day establishing the harmonious society, we should put the humanism into the sports theories, and integrate the competitive sports with the amusement. Chinese competitive sports will be not the political tool any more, and it will be the carrier of health and amusement for every Chinese (Hu, 2002). Therefore, in the competitive sports, for the design, arrangement, training, recovering and game of the actions, we all should fully consider the essential and most important factor, i.e. the human. In the establishment and the implementation of the training plan, in the drastic competition, and in the social competition leaving from the game field, we should fully consider the social attribute that athletes are social human, stick to raise human spirits, continually enhance human spirit ambit, fully respect human right, have a definite objet in view, taking athletes as the core, teach athletes in accordance of their aptitude, largely mobilize their training enthusiasms, change athletes’ passivity in the training process, change the situation that athletes will be forgotten out of commission, make athletes obtain coaches’ concerns in the training, make athletes obtain audiences’ favor in the competition, make athletes obtain the concerns from the society out of commission, and realize the humanism of the competitive sports (Ma, 2004).

Finally, the competitive sports should maintain the justice and realize the green justice of the competitive sports. The competition of the competitive sports is cruel and unmerciful and insists on the principle of the “survival of the fittest”, but it is opening and just, and the permanent philosophy is that the difference is the essential of the harmony, which also is the infinite charm for the sustainable development of the competitive sports. The principle of justice started from the competitive sports has been the concept pursued by the harmonious society, and the justice of the sports is the activator of the harmony among humans. As a sort of special value practice and spirit direction that humans grasp themselves and the world, the competitive sports are a sort of harmonious and nice project. Only in that way, the competitive sports can realize the “people-oriented” aim and embody the spirit of “cleaner, more humanism and more united”.

In conclusion, we think the people-oriented competitive sports are to inspire human biological energy in the body and create infinite space for the development. In the development and variance of the world sports culture, we deeply feel the negative effect of the national modernization to human development of body and mind, and as a sort of special measure against race degeneration, the meaning of the sports is very obvious. As one of the most valuable games in human living, the occurrence of the sports indicates that the human should not forget to cherish their beautiful body and biological power by the patterns such as training and competition. The human social activities are trying to develop and utilize various non-biological energies, and the human sports defend and inspire the biological energy from them. A sort of bright counterwork forms, and in the counterwork, the great philosophical meaning that the human invents the sports is really contained. The essential attribute of the sports is the social and cultural activity taking the body training as the basic measure and trying for the healthy development of body and mind and integrating characters such as competition, amusement, education and representation. Its foundation roots in human sport which only roots in the muscle shrinking like various sports. Without human muscle shrinking, there is not human sport, and without human sport, there is not human survival and human development. It is obvious that the sport which tries to dig human sports ability is the important mode to perfect human survival and development. For the importance of this mode however we try to understand and describe, it is not excessive or exaggerated (Ling, 2003).

3. System innovation: the system guarantee of the sustainable development for the competitive sports

The system innovation is the permanent topic about the healthy development for the human economy and society. At

present, the inertia of the “whole-nation system” in the competitive sports is very prominent, and it is obviously not seasoned with the function conversion of the government, the deep development of the socialism market economic system and the requirement of the sustainable development of the competitive sports. So we all put forward the problem about the system innovation of the whole-nation system, but the direction of the reform and the innovation still confuse human. We think that the persistence of the whole-nation system accords with the choice in the historical stage of Chinese sports project development, but we must effective reform and continually innovate the whole-nation system of the competitive sports, and establish the new whole-nation system with Chinese characters, vital forces and energies, advance with the times. The new whole-nation system of the competitive sports in the harmonious society is not only the “sports mechanism with Chinese characteristics which is dominated by the government, governed by the society and controlled by the market, and combines the market measure with governmental investment (Hao, 2005)”, but also the modern management mechanism with small investment and more outputs, high efficiency and low costs.

To establish “the new whole-nation system”, we should try to realize two transformations and two establishments.

The first “transformation” is to gradually realize the transformation separating government functions from sports management. The establishment of the new whole-nation system is to establish the running mechanism which is propitious to the harmony, the flexibility and the high efficiency of the competitive sports, to transform from the government management to the society management, and to transform from the administrative order management to the modern society management by the sports castes according to the laws. To establish the harmonious society and keep the advantage of the whole-nation system of the competitive sports, we must change the practice that the development of the competitive sports all depends on the administrative behaviors of the government, fully utilize the market mechanism to effectively integrate even inspire the sports resources of the whole country, and serve for the sustainable development of the Olympic strategy and the competitive sports. Therefore, we must constantly enhance the level of the competitive sports through the adjustment of the social mechanism and the market mechanism by the government and the market, promote the socialization and the industrialization of the competitive sports through the market mechanism, and finally realize the real “whole-nation system” of the competitive sports which the government, the society and the market harmonize and all people participate in. At present, the essential of the “whole-nation system” is that the sports administration right is highly centralized in the governmental sports administration department, and various sports centers can not separate their functions from the management, and various single sports associations really are assistances of various centers which still are governed by the government. At the same time, the potentials and enthusiasms of the society, enterprise and school to hold the competitive sports with high levels have not been really exerted, and the status of the civilian sports industry such as the occupational sports club has not been really enhanced. To establish the new “whole-nation system”, we must gradually realize the function-management separation according to the principle of “small government and big society”, and transfer the function in the various-level governments to relative enterprises, castes and agencies, and separate the function of the governmental sports administration management departs from the All China Sports Federation, Chinese Olympic Committee and various single sport association, and gradually realize the ordered harmony, ordered compensation and effective integration between the government and the market. The main function of the sports administration department should be transferred to carry out national policies, direct and management the competitive sports, constitute industrial policies and development plan of the competitive sports, manage and supervise the national financial investment to the competitive sports by the name of the country, and ensure the sustainable development and the harmonious development. All China Sports Federation should concretely lead and hold national competitive sports, and various single sports associations are concretely charged with relative games and training under the lead of All China Sports Federation. Chinese Olympic Committee can concretely assume the development of the Olympic sports in China. Actually, the government which assumes infinite rights and infinite obligations should be changed to the limited right and limited obligation, and the governments give away part rights which are assumed by new main body. But the rebuilding of the right and the benefit allocation can only be realized by the government predominance and compulsion of the whole-nation system, which is one of meanings in the system innovation of competitive sports.

The second “transformation” is to gradually realize the diversity of investment bodies. The characteristics of the whole-nation system of Chinese competitive sports is the instruction system of the government, and the government is the only main body of the development of the competitive sports, and the government has the decision-making right and the distribution right of the resources, and the government can compulsorily adopt the administration measures to make the resources and the development of the competitive sports close to the national aim, which is the advantage that the country can centralize all powers to do the big thing. At present, the socialization degree of Chinese competitive sports is not enough to produce amateurishly competitive sports, and the marketization degree can not support the occupational sports in the large range. Therefore, we can not simply give up the whole-nation system, and we should sustain even increase the financial investment of the competitive sports in quite a long time. However, the core of the competitive sports system is the instruction system of the government. After China confirmed the strategic objective of the socialism market economy, the systems of the society and the economy have been essentially changed, and the

mode that public ownership is dominant and different economic sectors develop side by side has occurred. That makes the system of the competitive sports transformed to the socialism market economy. The competitive sports with the whole-nation system don't face the single governmental investment any longer, but the multiple composite structure with social multiple investment bodies. So we should change the traditional government decision and government dominated mode to the mode that the government, the market, the non-profitable organization, the enterprise, the community and the family participate in together to make decisions and implement, compensate the deficiency of the governmental investment and ensure the capital source of the sustainable development for the competitive sports.

To realize the "first establishment", we should gradually establish the sports resource selection and integration mode taking the region as the base and taking the city as the center which is the time tendency for the sustainable development of the modern competitive sports, and is the necessary result of the socialization and the marketization of the competitive sports. There are many foreign experiences which can be used by us. With the development of the socialism market economy, the development of Chinese urbanization also offers certain conditions for the resource flow of the competitive sports. Therefore, the running of the new Chinese whole-nation system must change the former selection and training system, and change the past linear structure of "local amateur team to provincial team to national team" to the network selection and training mode taking the region as the based and taking the city as the main body. Concretely speaking, through the innovations of the management system, the training system, the game system, especially the talent selection system, we should gradually form the new whole-nation system which takes various big cities as the base, takes the market mechanism and the social self-rule as the main measures, takes various games as the important opportunities, effective bridges and drive powers, takes necessary governmental financial allowance and prize as the direction, to drive the sustainable development of Chinese competitive sports and further drive the process of Chinese urbanization, and promote the sustainable developments of the competitive sports and the social economy.

To realize the "second establishment", we should gradually establish the training and competition allocation that professional teams, occupational teams and amateur teams can exist the same time. For a long time, China had implemented the single training system of the competitive sports, and its main bodies include county amateur sports school, provincial professional sports team and national team. Under the condition of the socialism market economy, this sort of single professional competition and training mode has not suited for the demand of the development of the modern competitive sports, and we must discuss the running mode that professional teams, occupational teams and amateur teams can exist at the same time. We should fully utilize the policy guidance and the leverage of the capital investment from the government, and continually establish the professional teams for the Olympic strategy, and establish national training based in various big cities according to the principles such as national investment, industrial management, project bidding and strict auditing to ensure the sustainable development of the important events. At the same time, we should largely advocate the occupational educations with social self-rule and market-dominated and drive the developments of the occupational allies with high socialization and marketization, and the single sports association should completely break away from the government administration departments. We should also largely foster the school league matches and national league matches taking the middle schools and colleges as the main bodies, dig and develop the resources of the competitive sports in the school, establish a passel of complete sports famous school through the league matches, cultivate the brand schools of the competitive sports, develop the schools with high level competitive sports to be the bases of the sustainable development resources of Chinese competitive sports, and ensure their powers of the sustainable development.

4. Scientific selection: the cultivation mechanism of the sustainable development for the competitive sports

First, the talent resource is the first resource of the sustainable development for the competitive sports. The marketization of the competitive sports talent factor should be established and developed, and the reasonable selection, scientific cultivation and ordered flow of the competitive sports talents should be promoted. Especially after 1990s, the Chinese competitive sports talent flow developed from the departments to the region even the national range. But because of many problems such as idea concept, management system, value view and operation mode, the present sports talent flow still has large limits, for example, dealing with the talent shortage by talent storage, protecting the weak by limiting the flow, and manage the talent communication market by the planned mode. Therefore, we must quickly establish the talent cultivation system of the competitive sports in the market dominated by the government.

Second, the new reserve talent cultivation system combining sports and teaching should be established and perfected. For the reserve talent cultivation, both the demand of the development of the competitive sports and the young athletes' individual and family future should be considered, so the competitive sports can obtain sustainable development. Under the present situation, we should constantly walk on the road combining sports and teaching, integrate the resources of the amateur sports schools, cancel or unite county amateur sports schools with bad schooling benefits, and develop the amateur training in the school with good conditions. We should also push the club system in the middle and elementary schools, dig and cultivate promising talents of competitive sports. We should continue to expand the scale of the sports team with high level in the colleges, and favor more considerations to these colleges, and gradually form the reserve

talent cultivation system from the elementary school to the middle school and to the colleges. Therefore, the sports system, the society system and the education system should be emphasized at the same time, and they should compete and communicate each other, and form the reserve talent cultivation system with close connection and expedite transportation channels (Xia, 2004).

Third, the capital investment of the competitive sports reserve talents should be largely increased. According to the total allocation of the Olympic events by the country, we mainly ensure the main events in the Olympics, and effectively centralize and use the special outlay from the centre and the region to cultivate the main reserve talents, and adjust the proportion and the structure of the special capital investment of the reserve talents. At the same time, according to the classification management principle of the sports events, we should reasonably distribute human resource, material resources and financial resources and adopt the mode of investing before evaluating for the centralized national teams or the part of teams with centralization and decentralization. And for other teams with centralization and decentralization, the local government first invests in them, and when they obtain certain achievements in the games, we will compensate local investment by the one time encouragement and form the benefit and investment system.

Fourth, the training bases should be reasonably developed and constructed. For the location and the construction of the training bases, we must overcome past mistakes such as repetitive construction, single function, single project and low benefit, rebuild and readjust the existing bases according to the training effects and original bases, the principle of two enthusiasms from the centre and the region, strictly control their scales and quantities, and centralize all powers to establish about 10 bases. At the same time, according to the characters of the competitive sports such as science, comprehensive, fine and centralization, we should establish a few national comprehensive training bases with high level. We should continue to support and continually perfect the universities, especially the sports colleges, to establish their sports teams with high level, and offer favorable policies from the base construction and capital investment, and make them become into the new “growth point” of Chinese competitive sports in the 21st century.

Fifth, we should establish the evaluation index system about the competitive sports reserve talents cultivation. Reasonable encouragement system and correct evaluation have directional function and encouragement function. The total leading idea to evaluate the department and the coaches who take on the responsibility of fostering reserve talents should be strengthening the talents transportation and desalting the game places. For the talent transportation, we should emphasize the quality more than the quantity. For the quantity, we can divide the game classes into the international games (such as Olympics, World Cup and World Championship) and general international games (including World University Games and continental games) and national games, divide the achievement levels into three layers including record-breaking, winning gold, winning medals and winning top 8, and the weights of various classes should be separated. According to the comprehensive evaluation, we can form the final evaluations for the coaches on various layers and promote them based on the final evaluations. At the same time, the country and provinces should not only encourage the athletes and coaches who obtain predominant achievements, but the encouragement quantity should far exceed the salary amount of the lower class game to encourage coaches, especially the coaches from the grass roots to scientifically select talents and scientifically train athletes and put the emphases on the talent transportation for the country (Wei, 2002).

Sixth, the construction of the athlete security system should be quickened. With the continual sports reform and the continual perfection of the whole society security system, the establishment of the social security system of letterman has been the top priority in the present sports reform. The perfect social security system can not only promote the reasonable flow and optimized distribution for the sports talent resources, and guarantee athletes' legal rights, but fully enhance lettermen's competition and training enthusiasm, and it is the necessary measure to attract young people to join the team of the competitive sports. As the special group, the excellent athletes are national rare talents whose occupation has characters such as high investment, high risk, long period and uncertainty, so accordingly we must establish the social security system according with their occupational characters. China should invest certain capitals to establish the “athlete training and arrangement funds”, which can offer the guarantee for the athletes when they are out of commission and largely change the phenomenon of “they are star group yesterday, and they are weak group today”.

5. Reasonable allocation: the energy mechanism of the sustainable development for the competitive sports

The allocation of the sports events in the competitive sports is an important aspect for the resource allocation of the competitive sports, and it is also the important aspect to deal with the relationship between the scale and the benefit for the competitive sports. China has a vast territory, and the resources are not distributed evenly, and the conditions that various regions develop the competitive sports are different, and only we can reasonable arrange and allocate resources, and adjust measures to develop the sports events of the competitive sports according to the characters and conditions of various regions, and we can ensure the sustainable, stable and healthy development of Chinese competitive sports.

Strengthen the strongest events and develop potentially strongest events. For any country, even the country with the strongest competitive sports strength, it can not win in all Olympic events. China has accumulated abundant experiences in many years' practices, and the traditional strongest events have been formed. The predominance of the strongest

events is obvious in the world, and they promote that Chinese competitive sports level enters into the first group, and these strongest events include pingpong, badminton, dive, gymnastics and shooting. According to present strength and finite finance of Chinese competitive sports, we should mainly develop the strongest events and the potentially strongest events. Based on mainly developing the Olympic events, we should reasonably adjust the interior structure of the events with small events, and exert the optimal benefit of the strongest event allocation. The potentially strongest events means those events which have possess higher level and can be translated into the strongest events through increasing investment, for example, female swim, judo, swordplay, female volleyball and female hockey. And we have a passel of world class athlete in these events, and they can completely be the new increase point of the gold medal. Therefore, we should strengthen the implementation power of the "Project 119", strive for breakthroughs in track and field events and swim, largely change the tendency that the collective ball events slide down, hold the leading level in the female volleyball and female football, continually develop the potentially strongest events and extend the development space.

Optimize the competition structure. We must reform the traditional competition system and fully exert the multiple functions and the comprehensive benefits of the competition. Starting from the form, scale, event and cycle of the competition system, combining the diversification development tendency of the world competitive sports game and Chinese actuality, we should establish the macro competition control system combining the market with the plan, keep the basic balance of the competition quantity, promote the optimization of the competition structure, and lead the sustainable, reasonable and healthy development of the competition. At the same time, we should change many deficiencies of National Games such as too much events, unobvious emphases, large differences among various teams, unfair opportunities, too much awarded marks factors and complex marking schemes, further embody the policy that firstly develop the Olympic events, lead various regions to put their eyes on the talent cultivation and Olympic gold medals. The various city sports games should take cultivating the Olympic event reserve talents as the objective, take young athletes as the competitive objects, and lead the cities to develop the Olympic events with weak bases. The national single competition should take the competitive level as the competitive standard, fully encourage the enthusiasm of the allocation regions to cultivate the talents with high level in the strongest events, and promote the diversification development situation of the competitive sports in various regions.

Dynamically manage the Olympic and non-Olympic events. We should scientifically predict and care about the events change and development of the Olympics, and grasp the event tendency of the world competitive sports in time. For the events which may enter into the Olympics and suit for development and popularization in China, we should predict in time and mainly support them, which can make Chinese competitive sports level to always keep in the international leading status and really realize the sustainable development and the harmonious development.

References

- Bu, Te. (2007). Harmonious Sports: the Regression of the Sports Essential. *Journal of Inner Mongolia Normal University*. No.4.
- Haoqin. (2005). Socialist Market Economy and the Formation of the New-type whole-nation Effort System. *Sports Culture Guide*. No.3.
- Hu, Xiaoming. (2002). Bring Forth New Ideas in Theory of Chinese TiYu. *Sports Culture Guide*. No.1.
- Hu, Xiaoming. (2000). New Sports in New Century. *Journal of Physical Education*. No.5.
- Lingping. (2003). The Changes and Foresight of Chinese Sports Developing Idea. *Shandong Physical Education Institute*. No.1.
- Ma, Zhihe et al. (2004). Innovation on Cultivation System of Sports Talent Reserves in China. *Sport Science*. No.6.
- Pan, Yingxu & Zhong, Bingshu. (2002). Analysis of the Actuality of the Sustainable Development Research for Sports in China. *Sports Culture Guide*. No.6.
- Wang, Jinglian & Zhao, Chongzhen. (1997). Green Sports: the Combination Point of Western and Eastern Sports Sprits. *Journal of Inner Mongolia Normal University*. No.1.
- Weibing et al. (2002). Basic Problems and Causes Influencing Continuous Development of Competitive Sport in China and Measures Taken to Solve them. *Journal of Beijing University of Physical Education*. No.1.
- Xia, Duanyang. (2004). Issues of Sustainable Development in Chinese Gymnastics. *Journal of Tianjin Institute of Physical Education*. No. 4.



Carbon Dioxide Emission Savings Potential of Household Water Use Reduction in the UK

M.J. Hackett & N.F. Gray (Corresponding author)

Centre for the Environment, Trinity College

University of Dublin, Dublin 2, Ireland

Tel: 353-1-896-1639 E-mail: nfgray@tcd.ie

Abstract

The relationship between household water use and energy consumption was examined to establish whether the conservation of water within a domestic environment offers significant potential for saving energy, thereby reducing household carbon dioxide emissions. Average UK water usage is $55,121 \text{ L ca}^{-1}\text{yr}^{-1}$. The supply of this volume of water and its subsequent treatment by the water companies is equivalent to just $38.6 \text{ kg CO}_2 \text{ ca}^{-1} \text{ yr}^{-1}$, although this is not currently included in the primary footprint. So water consumption per se does not significantly effect CO_2 emissions. However, the heating water within the household using electricity requires $5,036 \text{ kWh ca}^{-1}\text{yr}^{-1}$, equivalent to a further $2,830 \text{ t CO}_2 \text{ ca}^{-1}\text{yr}^{-1}$ with 57% of energy associated with use of heated tap water. Using gas instead of electricity to heat water can reduce emissions by 63%, equivalent to an average reduction of $4.36 \text{ t CO}_2 \text{ yr}^{-1}$ for a standard household (2.4 occupants). Water efficient appliances and the careful use of heated water in the home could reduce average household water use from 151 to $73 \text{ L ca}^{-1}\text{d}^{-1}$ as well as the volume of water required to be heated thereby reducing related emissions by 58% or $1,662 \text{ kg CO}_2 \text{ ca}^{-1}\text{yr}^{-1}$, where electricity is used. Maximum CO_2 emission reduction is achieved by the use of solar collectors using gas as standby heating fuel. This, coupled with simple water conservation measures, emits as little as $130 \text{ kg CO}_2 \text{ ca}^{-1}\text{yr}^{-1}$ a potential saving of $2.7 \text{ t CO}_2 \text{ ca}^{-1}\text{yr}^{-1}$.

Keywords: Water conservation, Energy conservation, Carbon footprint, Carbon dioxide emissions, Water heating

1. Introduction

Water conservation is seen as a major factor both in ensuring sustainability of water supplies but also in saving energy and thus reducing CO_2 emissions (ICWE, 1992; POLIS, 2005; Brandes, 2006; Australian Government, 2007; McMahon *et al.*, 2006; Gray, 2008). However, little quantitative analysis has been performed to assess how effective a mechanism water conservation is in relation to household and personal CO_2 primary or direct footprint management. Existing CO_2 calculators or models do not include water use as a quantifiable CO_2 source factor; with water treatment and supply coupled with wastewater collection, treatment and disposal treated as part of the secondary or indirect footprint (Kenny and Gray, 2009a). Energy associated with water use within the home, which is primarily for heating and possibly pumping in a small number of cases, is hidden as a component of the household energy service bill which also includes space heating, lighting and the use of non-water associated household appliances (Kenny and Gray, 2009b). Space heating is normally the largest household energy user followed by water heating (European Environment Agency, 2001; Shorrock and Utley, 2003). However, due to improved building regulations and energy saving initiatives such as loft insulation, double/triple glazing reducing thermostats by several degrees, space heating is becoming increasingly efficient (DTI, 2006; BRE, 2007). Therefore, it is inevitable that as these improvements in household design are implemented, the relative importance of water heating as a source of household and personal energy costs and CO_2 emissions will increase even further in the future.

The aim of this study was to examine the relationship between household energy consumption and water use to establish whether reducing water usage yields significant CO_2 emission reductions. A number of specific questions are addressed: (i) Does reducing the volume of water supplied and/or wastewater treated reduce CO_2 emissions per household in terms of the energy used to treat and transport water and sewage; (ii) What are the energy or CO_2 sources and outputs associated with household water use; and (iii) What effect does water conservation actions within the household have on energy usage and CO_2 emissions.

2. Methods

The volume of water supplied and treated is based on the average UK water consumption rate of $151 \text{ L ca}^{-1}\text{d}^{-1}$ (Ofwat, 2006), with lavatory flushing and internal tap use the largest sources of household water use together accounting for more than 50% of consumption (Figure 1) (Jefferson *et al.*, 2000; MTP, 2007h). Water usage, associated energy use and

subsequent CO₂ emissions were calculated and broken down into inputs, which comprise water treatment and subsequent supply, and outputs, which is the collection, treatment and disposal of wastewater. Both of these activities are normally carried out by the water companies. Carbon emissions from water and wastewater treatment were taken from the UK industry average identified by Water UK (2007) as 0.29 and 0.41 tonnes CO₂ ML⁻¹ respectively (Section 3.1). Domestic processes included all energy-based activities relating to water use within the home, and in the majority of cases this is restricted to water heating. Energy associated with domestic water heating or other water related functions were determined from research literature, manufacturers' product specifications and personal communication with manufacturers (Vickers, 2001; Beko, 2007; Australian Government, 2007; Hoover, 2007; McMahon *et al.*, 2006; MTP 2007c, d, e, f, g, j; Whirlpool, 2007a, b). Mean energy values were calculated per litre of water heated and processed for a UK household not employing water conservation action. The processes considered were tap use, showering, bathing, lavatory flushing, dishwasher and washing machine use (Section 3.2). Energy data as kWh was converted into CO₂ emission figures using the 2006 UK conversion factors for electricity and natural gas of 0.562 and 0.206 kg CO₂ kWh⁻¹ respectively (Defra, 2008a,b). Unless stated, electricity was the fuel type assumed, however different fuel types were compared. The analysis was repeated for a household employing water conservation measures (Section 3.3).

3. Results and discussion

3.1 Reducing the volume of water supplied and/or wastewater treated reduces CO₂ emissions from the treatment of water and sewage.

Based on Water UK (2007) average company performance values, 0.29 and 0.41 g CO₂ are emitted for every litre of water supplied or wastewater treated respectively. Based on the average UK consumption rate of 151 L ca⁻¹ d⁻¹ this is equivalent to emission rates for water supplied and wastewater treated of 105.7 g CO₂ ca⁻¹ d⁻¹ or 38.58 kg CO₂ ca⁻¹ yr⁻¹. However, this emission source is currently included in the secondary rather than the primary household CO₂ footprint (Kenny and Gray, 2009b).

The household conservation measures tested in this study reduced water usage by 52% (Section 3.3) leading to a reduction in per capita CO₂ emissions during its production and disposal from 38.6 to 18.6 kg CO₂ ca⁻¹ yr⁻¹. With the carbon footprint of an average individual living in the UK currently estimated at 5.1 t CO₂ yr⁻¹, with the secondary footprint equivalent to a further 4.1 t CO₂ yr⁻¹ (Defra, 2006), then the saving of 20 kg CO₂ yr⁻¹ only represents 0.39% of an individual's annual primary CO₂ footprint, or equivalent of driving a modern 1.4 litre petrol car 126 km (Kenny and Gray, 2009b). However, when this is multiplied by the number of people connected to water mains and sewerage systems in the UK, then this figure becomes significant in terms of national emissions. In 2004/5 18,837 ML d⁻¹ of drinking water was supplied to the public distribution system (Gray, 2008) representing a daily CO₂ footprint of 5,463 t CO₂ d⁻¹ and a further 7,535 t CO₂ d⁻¹ for its subsequent treatment as wastewater. So, in England and Wales alone there are 52.7 million people connected to the mains so the potential saving for the water industry, if basic household water saving measures were introduced as described in this study, would be 1.054 x 10⁶ t CO₂ yr⁻¹. The current industrial, commercial and public CO₂ emissions in the UK is 242 x 10⁶ t CO₂ yr⁻¹ (Defra, 2006) so household water conservation would reduce these secondary CO₂ emissions by less than half of one percent overall. The extra energy costs associated with water harvesting, provision of a personal water supply or a wastewater treatment system are unlikely to be cost effective in terms of CO₂ emissions due to constructional, operational and maintenance energy inputs (Gray, 2008). Centralized water supply and wastewater treatment are always going to be more energy efficient, although conservation of water use in the home does make a small but cumulatively significant reduction in emissions.

3.2 The energy and CO₂ sources associated with household water use.

Ninety-nine percent of energy consumption and CO₂ emissions of the water use cycle occur during the domestic use of water, primarily through water heating. Water usage and energy emissions for appliances are given in Table 1 while their frequency of use in an average UK house of 2.4 occupants (Shorrock and Utley, 2003) is given in Table 2. This includes 248 dishwasher and 278 washing machine cycles per household per annum (MTP, 2007a,b) with frequency of use of the shower, bath, tap and lavatory based on conservative estimates of normal practice (Vickers, 2001; Gray, 2008). This results in a water usage rate of 55,121 L ca⁻¹ yr⁻¹, resulting in an energy consumption for domestic activities where electricity is the sole energy source of 5,036 kWh ca⁻¹ yr⁻¹ (Table 3) emitting 2.83 t CO₂ ca⁻¹ yr⁻¹, which is equivalent to 2.87 t CO₂ ca⁻¹ yr⁻¹ including water and wastewater treatment. Tap use is the largest consumer of energy within the home, accounting for 57% of energy consumed and CO₂ emitted and so offers the greatest potential for emission reduction.

As fuel mixes vary within and between households the overall total CO₂ emissions, including water and wastewater treatment can vary between 1,052 to 2,869 kg CO₂ ca⁻¹ yr⁻¹ due to the fuel mix alone. This indicates that the use of gas rather than electricity to heat water can save 1,818 kg CO₂ per annum on a per capita basis, a potential emission reduction of 63%. These results indicate that between 21 to 56% of the average UK primary CO₂ footprint can be accounted for by water heating, depending on the type of fuel used. This is slightly higher than previous estimates of

23% in the UK (Shorrock and Utley, 2003), the European average of 15% (EEA, 2001), and 28% in Australia (Milne and Riedy, 2007). However, the exact percentage depends on the estimated personal CO₂ footprint, the fuel mix and actual hot water usage.

It is in the use of heated tap water that the greatest variability in energy usage between households is seen and where the greatest potential savings can be made. Kenny and Gray (2009b) showed that per capita home energy use fell by 27 and 34% respectively in two and three person households compared to a single occupancy household. Tap water use is the only factor associated with water use that is significantly affected by occupancy rate. So, for example, if we assume a 30% reduction in hot tap water usage for an average household of 2.4 occupants then the annual energy usage would fall from 12,087 to 10,003 kWh (Table 3). However, in this paper we have not applied this correction factor due to a lack of actual occupancy usage data.

3.3 The energy and CO₂ sources associated with household water use where water conservation is applied.

Household water and energy consumption can be significantly reduced by using water and energy saving appliances and more careful use of water in the home (Table 1). Typically this includes dishwasher and washing machines that are A rated for both energy and water use, low-power showers fed directly from the hot water cylinder, low flow taps and low volume flush toilets, rather than the UK market standard. Usage is also assumed to have changed through better practice: dishwasher cycles reduced from 248 to 225 and washing machine cycles reduced from 270 to 250 per household per annum, shower use increased from 6 to 7 ca⁻¹wk⁻¹ to replace the possible weekly bath, and hot water tap use reduced from 6 to 4 minutes ca⁻¹d⁻¹ (Table 4). These actions would reduce average water use from 151 to 73 L ca⁻¹d⁻¹ (Tables 3 and 5). Thus the use of energy efficient water-consuming appliances and moderately reduced water usage rates can achieve savings of 1,662 kg CO₂ ca⁻¹yr⁻¹, equivalent to a net saving of 58% (Table 6).

In 2005 >5 million households in Europe employed solar collectors or panels to transform sunlight into energy for space and water heating (SEI, 2008). Solar water heating does not appear to be a complete alternative to gas and electricity; rather it is a supplement to these energy sources. The problem is that excess heated water is produced during the summer and not enough in the winter (MTP, 2007i). Overall 60-70% of household water energy needs can be met, although this varies with location (SEI, 2008). Over sizing the units may increase the volume of heated water in cooler months but this causes serious problems of wasting excess water and problems of overheating in the summer (Alternative Energy Ireland, 2008). Expected average water temperatures using correctly sized solar panels (ISO, 2001) and hot water cylinders, assuming 50 litres per person per household, for central UK will be Spring 45-55°C, Summer 80°C (restricted), Autumn 50-60°C and Winter 30-40°C (SEI, 2008). In practice this would reduce per capita energy used to heat water in the home from 5,036 to 1,542 kWh ca⁻¹yr⁻¹ (Table 7), a 69.4% reduction of energy, and CO₂ emissions equivalent to 1,964 kg CO₂ ca⁻¹yr⁻¹ where electricity is used. If gas only was used as the standby heating fuel with solar collectors, emissions associated with water heating would be just 318 kg CO₂ ca⁻¹yr⁻¹, a potential maximum reduction in the personal emissions footprint of 1,964 kg CO₂ ca⁻¹yr⁻¹. The use of conservation appliances and behaviour (Table 5) in conjunction with solar collectors would reduce the standby energy requirement even further to just 633 kWh ca⁻¹yr⁻¹, equivalent to just 130 kg CO₂ ca⁻¹yr⁻¹ using gas, equivalent to a potential emissions reduction of 2.7 t CO₂ ca⁻¹yr⁻¹.

The emission values in this paper are derived from industry standard values, and using average national consumption rates. However, consumption patterns, boiler types and efficiencies vary significantly between individual households. The study indicates that the more careful use of heated water in the home has significant emission reduction potential, although this needs to be confirmed through detailed household input-output studies of carbon emissions, and detailed analysis of energy saving of specific water conservation and water heating case studies.

4. Conclusions

- The industry related CO₂ emission per capita from the supply and subsequent treatment of wastewater at a consumption rate of 151 L ca⁻¹d⁻¹ is 38.6 kg CO₂ ca⁻¹ yr⁻¹. Current conservation measures can reduce this by 20 kg CO₂ ca⁻¹ yr⁻¹. The extra energy costs of subsidizing water supplies such as water harvesting, or the provision of personal water supply and wastewater treatment are unlikely to be sustainable options in terms of CO₂ emissions.
- Average UK water usage of 55,121 L ca⁻¹yr⁻¹ results in an energy consumption for domestic activities, where electricity is the sole energy source, of 5,036 kWh ca⁻¹yr⁻¹ emitting 2,830 kg CO₂ca⁻¹yr⁻¹, which is equivalent to 2,869 kg CO₂ca⁻¹yr⁻¹ including water and wastewater treatment.
- The selection of fuel type to heat domestic water can have significant implications on CO₂ emissions. Using gas instead of electricity to heat water can reduce emissions by 63%, equivalent to an average reduction of 4.36 t CO₂ yr⁻¹ for the standard household modelled.
- Water conservation measures could reduce average water use to 73 L ca⁻¹d⁻¹ reducing emissions by 58% or 1,662 kg CO₂ ca⁻¹yr⁻¹.

- Maximum CO₂ emission reductions associated with water use in households is achieved by the use of solar collectors and gas as standby heating fuel. This can be further reduced by the use of water and energy conservation appliances and behaviour which would emit just 130 kg CO₂ ca⁻¹yr⁻¹ a potential saving of 2.7 t CO₂ ca⁻¹yr⁻¹ compared to standard usage using electricity as fuel source.

References

- Alternative Energy Ireland (2008). *Solar energy*. Alternative Energy Ireland, Blessington, Co. Wicklow, Ireland. <http://www.aei.ie/> Accessed 19th June, 2008.
- Australian Government (2007). *Water Efficiency Labelling and Standards (WELS). FAQ*. <http://www.waterrating.gov.au/faq/index.html>. Accessed 31st May 2007.
- Beko (2007) *Washing Machines*. <http://www.beko.co.uk>. Accessed 16th August 2007.
- Brandes, O.M. (2006). *Thinking Beyond Pipes and Pumps*. POLIS Project of Ecological Governance, University of Victoria.
- BRE (Building Research Establishment) (2007). *Ecohomes and Ecopoints*. <http://www.bre.co.uk>. Accessed 31st August 2007.
- Defra (2006). 2005 Experimental Statistics on carbon dioxide emissions at local authority and regional level, Department for Environment, Food and Rural Affairs, London <http://www.defra.gov.uk/environment/statistics/globalatmos/index.htm> Accessed 19th June, 2008.
- Defra (2008a). *Guidelines to Defra's GHG conversion factors: Annexes updated April 2008*. Department for Environment, Food and Rural Affairs, London.
- Defra (2008b). *Guidelines to Defra's greenhouse gas (GHG) conversion factors for company reporting -annexes*. Department for Environment, Food and Rural Affairs, London.
- DTI (2006). *Strategy for Sustainable Construction*. Department of Trade and Industry, London. <http://www.berr.gov.uk/files/file37182.pdf>. Accessed 4th September 2007.
- European Environment Agency (2001). *Household energy Consumption*. Indicator Fact Sheet. http://www.themes.eea.europa.eu/Sectors_and_activities/households/indicators/energy/hh06households.pdf. Accessed 19th June 2008.
- Jefferson, P., Seaton, R.A.F., Parsons, S., Judd, S.T., Stephenson, T., Fewkes, A., Butler, D. and Dixon, A., (2000). An interdisciplinary approach to the assessment of water recycling technology options. *Int. J. Water*, **1**, 102-117.
- Gray, N.F. Gray (2008). *Drinking Water Quality*. 2nd edition. Cambridge University Press, Cambridge.
- Hoover (2007). *Washing Machines*. <http://www.hoover.co.uk>. Accessed 16th August 2007.
- ICWE (1992). *The Dublin Statement*. International Conference on Water and the Environment, Dublin.
- ISO (2001). *Thermal solar systems and components. Solar collectors. Test methods*. EN12975-2:2001. International Standards Organization, Geneva.
- Kenny, T and Gray, N.F. (2009a). Comparative performance of six carbon footprint models for use in Ireland. *Environmental Impact Assessment Review*, **29**, 1-6.
- Kenny, T and Gray, N.F. (2009b). A preliminary survey of household and personal carbon dioxide emissions in Ireland. *Environment International*, **35**, 259-272.
- McMahon, J. E., Whitehead, D.C. and Biermayer, P., (2006). *Saving Water Saves Energy*. http://www.mail.mtprog.com/CD_Layout/Day_1_21.06.06/1615-1800/ID167_McMahon_final.pdf. Accessed 14th August 2007.
- Milne, G. and Reidy, C., (2007). *Energy Us: Introduction*. Australian Greenhouse Office. <http://www.greenhouse.gov.au/yourhome/technical/fs40.htm>. Accessed 28th May 2007.
- MTP (2007a). *BNDH06: Ranking of energy saving measures in the home*. Version 5.2. Market Transformation Programme. <http://www.mtprog.com>. Accessed 30th March 2007.
- MTP (2007b). *Sustainable Products 2006: Policy Analysis and Projections*. Market Transformation Programme. <http://www.mtprog.com>. Accessed 11th July 2007.
- MTP (2007c). *BN DW Shower: Actions to improve shower design and efficiency – Briefing Note relating to policy scenario objectives in Policy Brief*. Market Transformation Programme. <http://www.mtprog.com>. Accessed 12th July 2007.

- MTP (2007d). *BNW21: EC Energy Labelling of Domestic Dishwashers: Current usage and future requirements for policy review*. Market Transformation Programme. <http://www.mtprog.com>. Accessed 14th August 2007.
- MTP (2007e). *BNDWBATHS: Actions to improve bath design and efficiency – Briefing Note relating to policy scenario objectives in Policy Brief*. Market Transformation Programme. <http://www.mtprog.com>. Accessed 16th August 2007.
- MTP (2007f). *BNWAT07: Baths – water efficiency performance tests*. Market Transformation Programme. <http://www.mtprog.com>. Accessed 16th August 2007.
- MTP (2007g). *BNWAT21: Performance standards for water-using products – an overview*. Market Transformation Programme. <http://www.mtprog.com>. Accessed 16th August 2007.
- MTP (2007h). *Product Overview: Water*. Market Transformation Programme. <http://www.mtprog.com>. Accessed 11th July 2007.
- MTP (2007i). *BNDH21: Solar water heating for housing*. Market Transformation Programme. <http://www.mtprog.com>. Accessed 16th August 2007.
- MTP (2007j). *BNWAT06: Showers – water efficiency performance tests*. Market Transformation Programme. <http://www.mtprog.com>. Accessed 16th August 2007.
- Ofwat (2006). *Security of supply, leakage and water efficiency*. 2005-06 report. Ofwat. <http://www.ofwat.gov.uk>. Accessed 19th June, 2008.
- POLIS (2005). *At a Watershed*. POLIS Project of Ecological Governance, University of Victoria.
- SEI (2008). *Passive solar energy*. Sustainable Energy Ireland, Dublin. <http://www.sei.ie/index.asp?locID=264&docID=-1#PassiveSolar> Accessed 19th June, 2008.
- Shorrock, L. D. and Utley, J.I., (2003). *Domestic Energy Fact File*. BRE (Building Research Establishment), London.
- Vickers, A. (2001). *Handbook of Water Use and Conservation*. Waterflow Press, Amherst, Massachusetts.
- Water UK (2007). *Towards Sustainability 2005-2006*. UK water industry Sustainability Indicators 2005/2006. Water UK, London. <http://www.water.org.uk>. Accessed 14th March 2007.
- Whirlpool (2007a). *Dishwashing*. <http://www.whirlpool.co.uk>. Accessed 16th August 2007.
- Whirlpool (2007b). *Washing*. <http://www.whirlpool.co.uk>. Accessed 16th August 2007.

Table 1. Mean water and energy consumption rates by domestic activity used for households employing market average (i.e. industry standard) water use appliances and in parentheses water conservation appliances, both using electricity as the sole energy source.

Appliance or Activity	Water use		Energy use	
	Litres per unit use	units	kWh per unit use	units
Dishwasher	17 (12)	L per cycle	1.21 (1.05)	kWh per cycle
Washing machine	63 (45)	L per cycle	1.09 (1.02)	kWh per cycle
Shower	33 (18)	L per shower	4.31 (2.28)	kWh per shower
Bath	86 (65)	L per bath	11.18 (8.45)	kWh per bath
Tap	10 (5.7)	L per min.	1.31 (0.74)	kWh per min.
Lavatory	5.2 (3.3)	L per flush	Not applicable	

Table 2. Estimated frequency of use of domestic water consuming appliances and activities for a standard UK household (2.4 occupants) consuming 151 L water $\text{ca}^{-1}\text{d}^{-1}$.

Appliance or activity	Number of uses per capita			Number of uses per household		
	d^{-1}	wk^{-1}	yr^{-1}	d^{-1}	wk^{-1}	yr^{-1}
Dishwasher (cycles)	0.3	2	103	0.7	5	248
Washing machine (cycles)	0.3	2	114	0.8	5	274
Shower (no.)	0.9	6	312	2.1	14	749
Bath (no.)	0.1	1	52	0.3	2	125
Tap (min.)	6.0	42	2,190	14.4	101	5,256
Lavatory (flushes)	5.0	35	1,825	12.0	84	4,380

Table 3. Average water and energy consumption rates for water consumption in the U.K. (151 L $\text{ca}^{-1}\text{d}^{-1}$) on per capita and per household (2.4 occupants) basis.

Appliances and activities	Water use (litres)				Energy use (kWh)			
	Per capita		Per household		Per capita		Per household	
	d^{-1}	yr^{-1}	d^{-1}	yr^{-1}	d^{-1}	yr^{-1}	d^{-1}	yr^{-1}
Tap	60	22,010	145	52,823	7.8	2,861	18.8	6,867
Shower	28	10,343	68	24,823	3.7	1,345	8.9	3,227
Lavatory	26	9,399	62	22,557	Not applicable			
Washing machine	20	7,193	47	17,262	0.3	124	0.8	298
Bath	12	4,472	29	10,733	1.6	581	3.8	1,395
Dishwasher	5	1,705	11	4,092	0.3	125	0.8	300
Total	151	55,121	363	132,289	14	5,036	33	12,087

Table 4. Estimated frequency of use of domestic water consuming appliances and activities for a standard UK household (2.4 occupants) employing conservation appliances and activities.

Appliance or activity	Number of uses per capita			Number of uses per household		
	d^{-1}	wk^{-1}	yr^{-1}	d^{-1}	wk^{-1}	yr^{-1}
Dishwasher (cycles)	0.3	2	94	0.6	4	225
Washing machine (cycles)	0.3	2	104	0.7	5	250
Shower (no.)	1.0	7	364	2.4	17	874
Bath (no.)	0.0	0	0	0.0	0	0
Tap (min.)	4.0	28	1,460	9.6	67	3,504
Lavatory (flushes)	5.0	35	1,825	12.0	84	4,380

Table 5. Water and energy consumption rates for water consumption using conservation appliances and approach in the UK (73 L ca⁻¹d⁻¹) on per capita and per household (2.4 occupants) basis.

Appliances and activities	Water use (litres)				Energy use (kWh)			
	Per capita		Per household		Per capita		Per household	
	d ⁻¹	yr ⁻¹	d ⁻¹	yr ⁻¹	d ⁻¹	yr ⁻¹	d ⁻¹	yr ⁻¹
Tap	23	8,322	55	19,973	3.0	1,082	7.1	2,596
Shower	18	6,370	42	15,288	2.3	828	5.5	1,987
Lavatory	17	6,023	40	14,454	Not applicable			
Washing machine	13	4,688	31	11,250	0.3	106	0.7	255
Bath	0	0	0	0	0	0	0	0
Dishwasher	3	1,125	7	2,700	0.3	98	0.6	236
Total	73	26,527	175	63,665	6	2,115	14	5,075

Table 6. Comparison of per capita energy and CO₂ emissions between standard water use and those employing conservation measures. ° Energy usage unknown as number of fuel mixes used.

Source	Standard water use			Conservation water use			Net saving		
	Water (litres)	Energy (kWh)	CO ₂ (kg CO ₂)	Water (litres)	Energy (kWh)	CO ₂ (kg CO ₂)	Water (litres)	Energy (kWh)	CO ₂ (kg CO ₂)
Inputs	55,121	- ^a	16.0	26,527	- ^a	7.7	28,594	- ^a	8.3
Processes		5,036.3	2,830.3		2,114.6	1,188.4		2,921.6	1,641.9
Outputs		- ^a	22.6		- ^a	10.9		- ^a	11.7
Total		5036	2,868.9		2,147	1,207.0		2,956.5	1,661.9

Table 7. Estimated per capita seasonal percentage replacement of water heating by passive solar collectors and standby energy requirement and saving under standard conditions described in Table 3.

Source	Normal energy required (kWh)	Replacement by solar heating (%)				Standby energy required (kWh)	Energy saving (%)
		Spring	Summer	Autumn	Winter		
Tap	2,861	60	95	75	50	858	70.0
Shower	1,345	60	90	70	45	454	66.3
Washing machine (40°C cycle only)	124	90	100	90	75	14	88.8
Dishwasher	125	80	100	90	65	20	83.8
Bath	581	60	90	70	45	196	66.3
Total	5,036					1,542	69.4

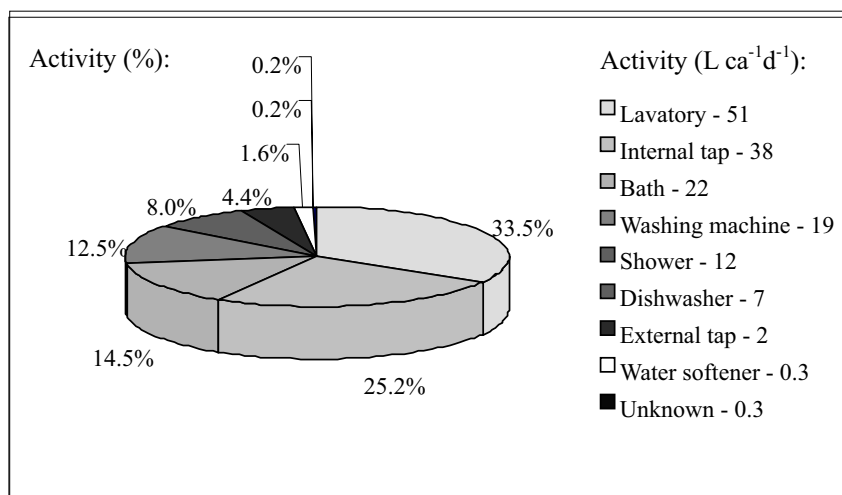


Figure 1. Household water use by activity, in England and Wales for 2007, on an actual (litres) and percentage basis (adapted from MTP, 2007i).



Study on the Leisure Sport and the Sustainable Development of People

Houzhong Jin

School of Sports Economics and Management

Central University of Finance and Economics

Beijing 100081, China

E-mail: jinhouzhong@126.com

Abstract

It is the ideal that the human being assiduously seeks to make each person develop freely and completely. The development of the productivity induces that human leisure time increasingly increases and the leisure space develops gradually, so the leisure culture is more and more concerned by the academe. The ecological leisure sport is closely related with human sustainable and complete development. It should be not only the organic composing of the leisure culture study but the effective approach promoting human sustainable, harmonious and complete development to strengthen the study of ecological sports leisure and enhance human ecological quality.

Keywords: Ecological philosophy, Ecological leisure, Sports leisure, Ecological quality, Ecological civilization, Human sustainable development

In the modern time, leisure has been one of the most important characteristics. The quality of the leisure, especially for the quality of the leisure mode, will directly influence the development of the economic society, the construction of the harmonious society and the complete development of people. In this article, we first analyze the leisure definitions in foreign and domestic academe and primarily understand and standardize the essential of the leisure, and further study the close relationship between the ecological sports leisure and human harmonious, sustainable and complete development from the dimension of the ecological leisure philosophy and harmonious sports theory.

1. Analysis of leisure definition

The famous leisure theory expert of the Health and Human Development Academe of Pennsylvania University, professor Geoffrey Godbey thought that “the leisure is a sort of relatively free life extricating from exterior pressures of cultural environment and material environment, and it can make the individual act by his favorite mode that he will feel valuable instinctively from the interior love, and offer the base for the belief” (Geoffrey Godbey, 2000, P.14).

Professor John Kelly of US University of Illinois who was the first world leisure and amusement association research committee president thought that “the leisure is understood as a sort of “becoming status”, i.e. the leisure is not the present and the practice, but the dynamic, and it includes many factors facing the future, and it is not only the existing form, situation and meaning (Johan Kelly, 2000, P.22)”, and “the leisure is the main social space to complete the human and social development, and it is a sustainable and important development stage in the whole life of people (Johan Kelly, 2000, P.104)”. Taking human healthy status as the example, human healthy status is decided by human daily living mode, leisure behavior, emotion and luck. Except for good inheritance from parents, the most important decisive factors of the human health include individual habit, daily behavior and collective action. If people keep good nutrition, persist in sports training and cultivate healthy habit, so human average life will be prolonged much longer (Geoffrey, 2000, P.133).

The famous scholar who first put forward the leisure culture theory in China is Yu Guangyuan. In early 1983, Mr. Yu put forward that though China emphasized the sports competition, but the researches about the competition and game except for sports were not enough. In Chinese higher colleges, there is no one course studying the game, there is no one specialty of game, and there is no one scholar to study the game. In July of 1994 when he gave lectures in Guangzhou, he further pointed out that the play is one of human basic demands, and we should study the science of the play, grasp the technology of the play and develop the art of the play. The play is the leisure, and the culture of the play is the leisure culture. In 1995, under his supports, the first leisure culture design center was founded in China, which further drove the rise and development of Chinese leisure culture (Ma, 1996, P.157-158).

Mr. Yu Guangyuan thought that when part of time in off hours were used in “leisure”, most people would feel easier in their leisure activities, i.e. the leisure was decided by the character of the activity which made people amused (Yu, 2002, P.41-43).

In the book of “the leisure time view”, Pang Yaohui thought that “the problem of the leisure time is an important social problem, and many problems such as how to make the time budget, how to scientifically utilize time, how to create conditions and properly increase leisure time, how to eliminate the useless consumption of the leisure time and develop the potential of the leisure time, and how to predict the leisure time and design the leisure culture should be urgently studied by us (Pang, 1985, P.16-17)”.

From above foreign and domestic scholars’ discussions about the meaning of the leisure, we thought that the leisure mode every man selects should accord with the individual personality, scientifically predict whether his favorite leisure mode, especially for the sports leisure mode, can bring physical and spiritual release and pleasure or directly or potentially influence complete development, and it is the effective approach and method for the leisure main body actively uses the healthy leisure mode to achieve the optimal opportunity and enhance individual quality, reduce the large pressure of the individual survival pressure, and reply the rapid development of the science and technology and quick work speed. As human leisure, the scientific attitude adopted by the leisure main body can more show the tendency of human complete development. Under the guide of scientific leisure theory, the leisure will be the important locale of the human complete and free development. In this social locale, the individual should represent the potential and quality from non-specialization and turn them into human essential power. As viewed from this meaning, the leisure is the important part in the human life process. Just as what Marx said, “the personality should be developed freely, so the necessary labor hours are not reduced for obtaining surplus-labors, and the social necessary labor should be directly reduced to the minimum, and because all people save time and create measures, the individual will develop in many aspects such as arts and science (Marx & Engels, 1979, P.218-219)”. So we think that the so-called leisure is the process that the individual scientifically select the mode suit for the personality especially by the scientifically effective and polite body-building mode in the part off-hours, and actively enhance the individual quality and scientifically and reasonably pursue the life meaning when he obtains the release and pleasure of the body and spirit. And it is not only the necessary process to make people “becoming people”, but the effective locale to make the individual beneficial in the lifetime, and the activity space for human complete and sustainable development.

2. Explanation of ecological sports leisure

In the 21st century, under the guidance of the developed countries, human is walking up to the time of leisure which is coming up to China building the socialism harmonious society. “The leisure time will more emphasize to fulfill human demands of spiritual culture and realize human self-development and self-value. And as the most active, interesting and beneficial leisure mode to amuse body and mind, develop friendship, maintain healthy and challenge selfhood, the sports will certainly be the important content of human leisure activity (Lu, 2005, P.360)”. And many problems such as what is the leisure sports and what characteristics does the leisure sports have will certainly be the hotspot problems for the theoretic circle, especially for the sports theoretic circle. Because China is facing the leisure time and the leisure culture and the leisure sports activity is starting, so the concept of the leisure sports with consensus in Chinese sports theoretic circle. From the meanings of leisure, sports culture and human self-development, we think the leisure sport is the sports activity that human actively participate independently, freely exert the creativity, seek the release of body and mind, obtain pleasure psychological experience, continually enhance the life quality and pleasure index, and realize human complete development. Here, we know the free dominant time and independent participation is the precondition of the leisure sports, and the sports activities out the free dominant time and independent participation will not be the leisure sports. For example, some department organizes the basketball game at Wednesday, and it is the sports activity, and it is not the sports leisure, because the game is not played in employees’ freely dominant time, and it is hard to ensure all employees all like the basketball and would take participate in the game. The creativity, relaxed body and mind and psychological experience are the start and the approach to enhance the life quality and the happiness index and finally realize human complete development. Human self-development and complete development is a process, and in this modern society that the information, knowledge, science and technology develop very quickly and in the living that the high efficiency, quick cadence and drastic competition are the basic survival modes, people try to walk out the condensed space and time, eliminate the feeling of anxiety, look forward to the sense of security and find back the spirit home. Therefore, the leisure and the leisure sports have been a sort of basic psychological demand for modern people. In the freely dominant time, people can independently participate and create rich and colorful leisure sports activities by their favorite mode, seek the release of body and mind, obtain charmed psychological experience, gradually enhance the life quality and happiness index, and finally realize the complete development of people. The realization of human complete development is the final object of the leisure sports, and whether for the release of body and mind, or the psychological experience, or the enhancement of life quality and happiness index, it should achieve the complete development of people, or else, the release of body and mind and the psychological experience will lose meanings, and the leisure sports will be meaningless.

From the concept, the leisure sports possess three significant characteristics, i.e. the characteristic of independence, the characteristic of happiness and the characteristics of creation. For the independent sport, whether for the dominance of the time or for the selections of measure and mode and the pursuing of the object, the leisure sports should fully reveal

the individual independence, and it doesn't possess the characteristics of compulsion and restriction, which is the most significant characteristic different with competitive sports and school sports. The leisure sport is that human select their activities in their free time, and they can fully express their feelings and their tastes, and show their personalities and walk out the mechanization and modularization of the labor in the sports space without material gains and result restriction. Therefore, as a sort of living mode of self-selection and self-realization, the leisure sports offer uncommon opportunity and infinite space for the development and the expression of the personality, which means the sufficient independence right. For the happy sports, we can find happiness from our favorite work, study, achievement and family living, but in the real society and living, the process to look for this sort of happiness is suffering and brutal, and only in the leisure sports, human can find the release of body and mind, express the pleasure of mood, and experience the meaning of life, that means the leisure sport is the happy experience. The acquirement of happy experience in the leisure sports is decided by the participators' devotion and impetus, and more devotions will obtain stronger happy experience and achieve the "peak experience" (Maslow), at the same time, it is decided by the social interaction among participators. For the creative sports, in the leisure sports, people relax their bodies and minds, experience gladness, return the home of imagination and freely create the personality. People will hardly possess relaxed body and mind, happy experience and the air with the imagination when they don't get rid of nervous minds, worrying veins and dangerous mind frame. Without the imagination, there are not creation and innovation. When we face opening adventure and unrestricted behaviors, we can fully exert the free imagination and creativity, and feel that the sport is the activity which is dominated by human, and the leisure sport is the expression of their ideas and wills, the activity enjoyment of physical strength and potentials, and the individual self-realization, so it is the sport with imagination and creativity.

The quick development of the society and the advancement of the science and technology can bring human more abundant leisure activities than anytime in the past. Except for leisure sports, the surf the Internet, the movie and TV, the press and books, and the music and arts offer numerous leisure selections for people. We can classify the leisure sports from different angles, and from the angle of the leisure, the sports culture and the human self-development, the ecological leisure sport is the most essential and core sports mode.

"As a sort of mode to actively participate in the living, the leisure is a sort of ambit and idea, and a representation of human social civilization. In the east that the agricultural civilization is accumulated profoundly, especially in China which is the representation of east Asian civilization, the leisure possesses its own cultural characteristics, and it emphasizes the direct taste of body and mind in the nature, and it is embodied as more ecological and cultural leisure culture (Hu, 2005, P.377)".

The leisure sport has important practical meaning for the construction of the modern harmonious society. Chinese nation all along advocate the nature, devote the nature and develops harmoniously with the nature. In the ecological leisure sports time, we should use part of them to enjoy the survival materials and fulfill the physiological natural ecological demand, and at the same time, it is necessary to use quite part of time to consume the development materials and enjoy the materials, and make the human intelligence, the physical strengths and the ecological civilization accomplishment including the ecological taste and ecological quality, and even the good personality to be ecologically developed completely and freely. And it is one of effective approaches and measures to utilize the factor of the beauty, especially the factors of the ecological beauty, the sports beauty and the healthy beauty to educate people by the aesthetic feeling and taste.

Taking the ecological beauty as the object, the ecological sports leisure enjoys the ecological art beauty, perceives the natural ecological beauty, builds the manual ecological beauty, especially pursues the sports healthy beauty, and enhance the individual ecological quality and ecological ethic feeling in the dynamic process to make the leisure main body participate in the ecological system full of lives and harmonious beauty.

First, enjoy the ecological art beauty. Through the course of the civilization, the civilization is the symbol of the cultural advancement degree. For its connotation, the civilization is relative to the wildness, wildness and ignorance, and it indicates the degree of the human social advancement and the civilized status. From general meaning, the "culture" includes all results (material, spiritual, active and negative) of human activities, and the "civilization" means the active results of human activities. As viewed from the layer of getting to the root of a matter, which sort of "civilization" and "culture" can leave the natural ecology? Look up the welkin, the sun and moon shine, and overlook the earth, the mountain and river are beautiful, and human contains heroes in the universe, and human are affected by the nature, study from the universe and the nature, so the civilization is created. The natural civilization can not only be integrated in the universe, but draw near everything on earth, and the colorful literary talent, bright and beautiful grass and wood, charmed springs and stones, sounds of nature compose the picture interlaced by sounds and colors. Even the nature without any knowledge contains beautiful pictures, how about the human heart?

For the Chinese Tao, the idea is guided by the nature, and the art opinion is to take the nature as the highest taste principle, i.e. "the universe with the largest beauty is silent, and the time with definite rules discusses nothing and

everything on earth with constant reasons speaks nothing. The saint can enjoy the beauty of the universe and understand the truth of the universe, so the holy man does nothing and the mahatma acts nothing to view the universe". Remote sky and broad earth show the great and simple ecological art beauty by the wordless form. For the taste, to enjoy the ecological art beauty is to pursue the aesthetics idea of "natural go vulture act the role offing". The beauty should be felt and experienced. And real beauty exists in the universe mixed with nature. The ecological art beauty is the "beauty of the universe", and it "possesses everything on earth and travel in the outer space, clouds and winds". The sounds of nature in the ecological art beauty root in the beauty of the nature, and it is the highest aim of the taste (Fu, 1996, P.4).

Second, perceive the natural ecological beauty. The natural ecological beauty is the product of the nature through mechanical, physical, chemical, biological and long-term self-organized evolvement, and it presents the original and wide beauty in thousands of postures, includes various sorts of biology full of vital forces and energies, and embodies the beauty of the wonderful article excelling nature. Of course, "the profound perception to the ecological beauty can not stay on the sensible forms such as exterior color, form and symmetry, but go deep into the contents of ecological rules and ethic standards relative to life and organically uniform the truth, the honest and the beauty (She, 1994, P.50-55)". The main body who takes enjoying the ecological beauty as the leisure mode can directly obtain the spiritual enjoyment, the nature of the sentiment and the enhancement of the taste, develop and cultivate scientific, healthy and massive ecological value opinion and idea, harmonious and great ecological ethic affection, and further universally enhance the individual ecological leisure sports quality and effective drive human complete development course.

To perceive the natural ecological beauty, people should respect the "specialization" of the biological survival and maintain the "ecological status" of the biological activity. Just as what German famous philosophic anthropologist Michael Landman said, "because specialized apparatus and instinct, animals are limited in the very special exterior living condition and they can survive only in the living condition. Every animal species exists in a special living space (habitat), and many animals only live in the deep of the sea, and some other animals only inhabit in boscages (Michael, 1988, P.176)". The "ecological status" also expresses the similar meaning, i.e. certain species will occupy certain status in the ecological system because of its highly specialized living mode. "Specialization" and "ecological status" remind people to perceive the natural ecological beauty, follow the natural ecological rule and implement the ecological sports leisure.

Third, build the manual ecological beauty. The manual ecological beauty is to reasonably utilize, skillfully process and properly change the nature and further enhance the original natural ecological beauty under the premise that human follow the ecological rule and the creation rule of the ecological beauty by the green science technology and ecological technical principle. It requires people actively participate in the construction of the manual ecological beauty, exert the education function of the leisure main body, and pursue the truth, the honest and the beauty on the higher layer. Here, the truth, the honest and the beauty have special meanings. "the truth is presented as the true of the natural ecological rule, and the honest is presented as human correct natural view, and the beauty is presented as the harmonious intergrowth of human and other biological species and the natural environment (Yang, 2000, P.33)".

To build the manual ecological beauty, we should specially pay attention to the "harmonious beauty" and the "energy beauty" between the biology and the environment. And the "harmonious beauty" and the "energy beauty" are just the important characteristics of the natural ecological beauty. The harmony and the energy are the value which can make the life full of vigorous vital force and sustainable life force, the whole biological system follow the material cycle, energy conversion and information communication rule, and make the natural ecological environment of the earth keep youth forever, and make the ecological leisure main body really feel the life energy and harmonious beauty integrating the nature with the body and mind, purify human natural ecological soul in the happiness enjoying high-layer ecological sports leisure, enhance human spirit ecological ambit and protect human survival environment value.

To build the manual ecological beauty, we should also strengthen the "creation beauty" and the "participation beauty", and the natural ecological beauty is built by the propagation, the microorganism and the non-biological environment together in the mutual evolvement, and the manual ecological beauty is built by the human creativity when human follow the ecological rule, and it is also the ecological resultant force formed by the human creativity and the natural creativity. The manual ecological beauty roots in the natural ecological beauty and exceeds the natural ecological beauty. The ecological leisure main bodies consciously create and participate in these manual ecological beauties, deeply experience and fully embody the creation beauty and the participation beauty of the leisure sports main bodies, for example, experiencing the tree planting in the ecological tour leisure of Inner Mongolia, participating in the activity of defending the mother river and building the Reader forest.

Finally, pursue the sports beauty. It is the practical process, the ideal aim and the highest ambit pursued by the modern human leisure culture. WHO defines the health as that the health means the integration and the goodness of the body ability, the spirit ability and the social ability. WHO thinks that the health is "the complete status of the whole body and mind and the sociality, not only the status without diseases or the weak status".

The healthy beauty standard of WHO includes proper avoirdupois, symmetric body, harmony of head, shoulder and

stern, plump muscle, elastic skin, the hair with shines and without scurf, bright eye, acute reaction, neat teeth, the gum with normal color and luster, resisting universal colds and infections, possessing abundant energy and shouldering daily life and heavy work by easy stages without fulsome intensity and tiredness, active attitude, optimistically dealing with affairs, being willing to assume responsibilities, being good at rest, disciplinary living, being good at intelligence, strong emergency ability, adapting various changes of the exterior environment. It indicates the change of the human ecological sports mode. From the competitive sports pursuing the higher, the quicker and the stronger to the universal sports leisure, we can see the complete combination of life and beauty, see the sublimation of human spirits and see the life and hope. It possesses all meanings of human sports leisure and healthy beauty from the universal meaning. And it can undoubtedly bring the pleasure of taste for people.

3. Ecological leisure sports and human sustainable development

The academes usually grasp the contents, the conditions and the implementation approach of human sustainable and complete development mainly from the layers such as the transformation of the social system and the perfection of the social relationship, but they always ignore the important function and active meaning exerted by the ecological environment and the leisure especially the ecological leisure sports in human complete development, so we should give deep research and sufficient emphasis.

First, the orderly cycle and healthy operation of the ecological environment system are the natural premise and the necessary condition of human complete and sustainable development. Human is not only the survival of the nature, but also the survival of the society, and it is the opposite unification of both sides. Therefore, the nature and human have not only the adaptability, but also the inadaptability. For the adaptability, on the meaning of human biological attributes and natural existence, the nature offers the basic conditions of human survival and development, such as wide earth, clean freshwater resource, measurable light and heat conditions, feasible temperature and humidity, fresh air quality, abundant propagation resource and other various ecological environment resources, which compose the biosphere that the human survival and development can not leave all the time. If there is not the adaptability, there is no the generation of the human being, even more the development of human being. Therefore, “the human is the natural existence directly. As the natural existence with life, human possess the natural force and the life force, and human exists dynamically, and as the gifts, talents and desires, these forces act on the human, on the other hand, as the natural, material, sensible and objective existence, like propagation, human are restricted and limited, i.e. the object of human desire exists outside the human independent of the object (Marx & Engels, 1974, P.167)”. “If one existence has no its own nature outside the existence, it is not the natural existence and it can not participate in the living of the nature (Marx & Engels, 1972)”. Therefore, human should and must protect the natural ecological system.

For the inadaptability, from human social attribute and cultural existence dimension, through the human have “broken away” from the nature and been the “opposite”, but they have to contact with the nature and obtain the living materials for the survival and development. However, the resources and energy sources of the earth are not infinite, and the nature will not automatically fulfill various demands of human survival and development. The nature only offers the possibility of human survival and development, but to make the possibility change to the reality, it still needs human to recognize, utilize and change the nature, and protect, construct and perfect the nature to create the value. As the opposite unification of the natural existence and the social existence, the human construct the harmonious and graceful ecological environment, which equals to construct the natural base of human survival and development, and also equals to construct the material premise of the economic and social development, and accordingly make for the valuable demand of human survival and development. By contraries, to destroy the orderly natural ecological environment equals to destroy the natural condition of human survival and development, i.e. to destroy the precondition of the economic and social development, and to deviate from the beneficial pursuit of human survival and development.

Second, the organic gestation and development of the ecological sports leisure are the effective approach and the approach dependence of human complete and sustainable development. The association of the time and human complete development had be early founded by Marx, “the time is the space of human development (Marx & Engels, 1972, P.195)”, “the time is human active existence in fact, and it is not only the size of human life, but the development space of the human being (Marx & Engels, 1979, P.532)”, “the free time is the time which can be dominated freely, and the time can not be absorbed by the direct labor, and it is used in rest and amusement to cut broad space for the free activities (Marx & Engels, 1975, P.281-282)”. Marx had highly evaluated the basic function of the free time on human complete development, and he pointed out that “the development of whole human being is to utilize the free time for the human natural existence, and the precondition of whole human development is to take the utilization of the free time as the necessary base (Marx & Engels, 1975, 216)”.

Therefore, in the leisure time, the human should create the social ecological space for them to survive and develop, especially develop and create and utilize the time-space and condition of the ecological leisure and the sports leisure, which can quicken human complete development, and make us to find the development history, existence status and future orientation of the leisure time in the social-ecological space, so we can see that the human can consciously dig

their real essential power and actively advocate the humanism leisure mode and complete development consciousness, and it reflect the human profound understanding, deep cognition and grasp to their ecological sports mode and development mode. In the long river of human history, the leisure time actually has participated in the coagulation of all material and spiritual civilization results, and in the present and future process, the ecological leisure time will more obviously participate in human material and spiritual accumulation of the human society, especially for the ecological civilization results. So, it is not only the important measure to evaluate human self-development, but also the important parameters to measure human complete development.

From the leisure theory, human complete development is also be embodied in the saving of time, because the time distribution of various activities decides the social development degree and human development space level. Marx said, "Just as the individual, the social development, the social enjoyment and the social activity are all decided by the saving of time. And all savings are the saving of time in the final analysis (Marx & Engels, 1979, 120)". On the other side, to reduce the necessary labor time and increase the free leisure time equal to expand the space of the individual and the social development. Therefore, it is not only the symbol of social advancement, but also the basic premise, necessary condition and important guarantee to promote human complete development.

Third, the sustainable cultivation and enhancement of the environment protectable ecological quality is the implementation condition and the important guarantee of human complete and sustainable development. As before, the ecological leisure sport is the activity mode that the leisure main bodies enjoy the ecological art beauty, perceive the natural ecological beauty, build the manual ecological beauty and pursue the sports beauty, i.e. the leisure mode on the higher layer that the leisure main bodies take the ecological beauty as the leisure objects, and effectively cultivate and completely enhance human ecological quality through this leisure mode, and drive the course of human ecological civilization and promote human complete development.

We think that the ecological quality is the interior of human being which takes the ecological world view and the ecological methodology as the core, takes the ecological value view and the ecological ethics as the references, and takes the ecological thinking mode and the ecological behavior criterion as main contents and representation form. It embodies the main composing of present and future human quality and the dominant tendency of human complete development. In the new century, the ecological development of the productivity, the optimal perfection of the ecology and the free and complete development of human being all can not leave the effective enhancement of human ecological quality and the sustainable development of human ecological civilization. With the continual increase of human leisure time, especially the ecological leisure sports time, and the gradually development of the leisure space, especially the ecological leisure sports space, the human being is obtaining complete and sustainable development in the process continually utilizing, enjoying and creating the ecological leisure sports.

References

- Fu, Daobin. (1996). *Singer's Paradise: the Naturalism Spirit of Chinese Culture*. Harbin: Northeast Forestry Press. P. 4.
- Geoffrey Godbey, interpreted by Kangzheng. (2000). *Leisure in Your Life*. Kunming: Yunnan People's Publishing House. P. 14.
- Geoffrey Godbey, interpreted by Zhang, Chunbo et al. (2000). *Leisure and Leisure Service in the 21st Century*. Kunming: Yunnan People's Publishing House. P. 133.
- Hu, Xiaoming. (2005). Theory of Well-off Society Sports Leisure and Amusement. *2005 National Sports Development Strategy Seminar Corpus*. Beijing: Beijing Sports University Press. P. 377.
- Johan Kelly, interpreted by Zhaoran. (2000). *Making for Freedom: New Theory of Leisure Sociology*. Kunming: Yunnan People's Publishing House. P. 22, 104.
- Lu, Yuanzhen. (2005). The Strategy that China Enters into the Leisure Time and Develops Sports Population. *2005 National Sports Development Strategy Seminar Corpus*. Beijing: Beijing Sports University Press. P. 360.
- Ma, Huidi. (1996). Leisure: Building the Beautiful Spiritual Family for Human Being. *Xinhua Digest*. No. 12. P.157-158.
- Marx & Engels. (1975). *Karl Marx and Frederick Engels (Volume 26(3))*. Beijing: People's Publishing House. P.281-282, 216.
- Marx & Engels. (1974). *Karl Marx and Frederick Engels (Volume 42)*. Beijing: People's Publishing House. P. 167.
- Marx & Engels. (1979). *Karl Marx and Frederick Engels (Volume 46)*. Beijing: People's Publishing House. P. 120, 218-219, 532.
- Marx & Engels. (1972). *Karl Marx and Frederick Engels (Volume 2)*. Beijing: People's Publishing House. P. 195.
- Michael Landman. (1988). *Philosophical Anthropology*. Shanghai: Shanghai Translation Publishing House. P. 176.

Pang, Yaohui. (1985). The Leisure Time View. *Xinhua Digest*. No.7. P. 16-17.

She, Zhengrong. (1994). Philosophical Consideration about the Ecological Beauty. *Studies in Dialectics of Nature*. No.8. P. 50-55.

Yang, Guihua. (2000). *Ecological Tour*. Beijing: China Higher Education Press & Springer Press. P. 33.

Yu, Guangyuan. (2002). For Society Where Leisure is Enjoyed by All. *Studies in Dialectics of Nature*. No.1. P. 41-43.



Geo-information Science for Sustainable Development of Mount Stong F.R., Kelantan, Malaysia

Kamaruzaman Jusoff (Corresponding author)

School of Forestry & Environmental Studies

Yale University

205 Prospect St, New Haven, CT 06511, USA

Tel: 20-3-432-1384 E-mail: jusoff.kamaruzaman@yale.edu

A.K Skidmore

Department of Natural Resources

International Institute for Geoinformation Science & Erath Observation

ITC, Helongstraat 99, P.O.Box 6, 7500 AA Enschede, The Netherlands

Tel: 31-53-487-4276 E-mail: skidmore@itc.nl

Abstract

The state of Kelantan covers an area of 1.5 million hectares of which about 894,271 hectares or 60% is under forest cover. It is still very much endowed with a rich and diverse biodiversity, such as in the dipterocarp forests of the reserves, in the National Park, limestone hills of Gua Musang, mountain forests of the Main Range, and Virgin Jungle Reserves. It is fortunate in that it has vast areas of lowlands, high rolling mountains and hills, with a rich and unique biodiversity associated with those ecosystems. A scientific expedition to the Mount Stong Tengah Forest Reserve in 2003 discovered that the area has a unique and diverse ecosystem, rich in bio-diversity and many endemic species. These findings prompted the State of Kelantan to gazette the entire central Mt. Stong Permanent Forest Reserve, one of its prime production forests, totaling 21,950 hectares, into a state forest park. Consequently, the State Forestry Department of Kelantan planned to turn these mountain forest resources into the best managed and successful state forest park and to achieve this, an integrated and multi functional approach has to be adopted. Initially, a thorough study of the mountain forest park resources involving Universiti Putra Malaysia-Aeroscan Precision (M) Sdn Bhd's airborne hyperspectral imaging technology system has been undertaken. Preliminary results indicated that airborne hyperspectral sensing can easily identify individual timber species, estimate their timber volume, locate and map cultural, historical, mountain peaks, caves, waterfalls, picnic and camping sites potential and suitable for forest eco-tourism and recreational activities in Mt. Stong to be developed as a state forest park. Once completed, a 100 Year Management Plan will be formulated to assist the state government to undertake the best strategies towards implementing programs such as forest eco-tourism, publicity, local or international events, research facilities, and infrastructure, appropriate for a best managed and successful mountain state forest park.

Keywords: Airborne, Hyperspectral sensing, Sustainable development, Mountain forest, State Forest park

1. Introduction

Effective management of tropical mountain forest resources which are complex, especially in Mt. Stong, Kelantan requires accurate and up-to-date information to guide the data collection, such as cloud cover. To help the State Forest Park Manager make critical management decisions on the recently gazetted entire central Mt. Stong State Forest Park (21,950 ha), they need geo-spatial data in the forms of map and real-time digital data in an integrated system where it can be easily and quickly gathered, organized, analyzed and mapped to find patterns and relationships that were previously unrecognized. This in turn gives them a deeper understanding of the issues they face, and lets them bring more information and less conjecture to the problem solving process. The airborne hyperspectral sensing/GIS fills this gap by providing spatial analysis tools to support decision making. The objective of this paper is therefore to demonstrate the capabilities of a UPM-APSB's AISA airborne hyperspectral imaging sensor in developing management principles of developing Mt. Stong mountain forest as a State Forest Park The proposed Management Plan establishes broad principles for the development, management and planning of the Mt Stong as a State Forest Park and provides a series of best management practices (BMP) and actions based from an airborne spectral imaging technology. The primary aim of this

BMP is to ensure that the mountain forest resources of Mt. Stong is managed as a State Forest Park in an environmentally sensitive, sustainable and economically viable manner. It also seeks to ensure that managing Mt. Stong is a continuous process, responsive to changing local people expectations and expanding knowledge of the forest ecosystem.

2. Current status of forest resources in the state of Kelantan

Kelantan is the northern-most state on the East Coast of Peninsular Malaysia. It has an area of 1 493,181 ha or 14,931 km² of which about 894,271 ha or 60% is under forest cover (Dahlan and Abdullah, 2006). The state is steeped in tradition and culture with vast stretches of tropical forests. The total forest area in Kelantan state Forest Management Unit (FMU) amounts to 894 271 ha. Of this total, 629 687 ha were gazetted as Permanent Forest Estate (PFE), 108,783 as National Park/Wildlife Reserves, and the remaining 155,801 ha categorized as Stateland Forest (Table 1).

It is still very much endowed with a rich and diverse biodiversity, such as in the dipterocarp forests of the reserves, in the National Park, limestone hills of Gua Musang, montane forests of the Main Range, Virgin Jungle Reserves etc. It is fortunate in that it has vast areas of lowlands, high rolling mountains and hills, which therefore possess many species of plants and animals associated with those ecosystems.

<<Table 1. Land Status In Kelantan>>

As required under the National Forestry Act 1984, the Forest Reserves (F.R) within the state covers 629,687 hectares, which are categorized into 12 classes (an additional class solely under State Park in Kelantan). As can be seen from Table 2, the total area for conservation in the State (No.2-7) covers an area of 78,682 hectares and together with the National Park (108,783 ha), these accounts for 187,465 or 12.55% of the land area in the state, which is well above the area required by IUCN which is 10% of the land area (1,493,181 ha)

<< Table 2. Forest Classification In Kelantan>>

The overall rapid development in the country and the awareness for the need to conserve forest areas for the environment, biodiversity, recreation etc. has prompted the idea for a state park in Kelantan. To strengthen the case for a state park in Kelantan a suitable area requiring some basic information had to be selected. A scientific expedition, with the participation of scientists from universities, research agencies, non-governmental organizations and government agencies, organized in central Mt. Stong F.R in the western region of Kelantan from lowland forest to hill forest. The wide-ranging form of vegetation and wildlife as well as diverse physical features was favorable towards the establishment of a state park here. The findings were presented in a seminar on the 24-25 February 2004 attended by various agencies and state dignitaries. The seminar wholeheartedly endorsed that the central Mt. Stong F.R be turned into a forest park and the need for the Forestry Department to speedily submit the proposal to the State Government.

3. Description of the project area

Mt. Stong State Forest Park, which occupies the whole of central Mt. Stong F.R of 21,950 hectares in the mid western region of Kelantan (Figure 1), is under the administration of the West Kelantan District Forest Office. It is accessible from a number of routes i.e. from Jeli from the north and Gua Musang from the south. Presently the Stong Hill Resort is located at the entrance of the Park. The Stong Forest Park covers three different forms of forest ecosystem ranging from the hill dipterocarp forest to the upper hill dipterocarp forest and the montane forest. Mt. Stong is one of Kelantan's highest (1,442 m) mountains in the forest reserve. It is also part of the Stong Magmatite Complex forming the mountainous landscape. At each internal geological process of injections of magma granite, G. Stong is one of the only two locations in Malaysia. In addition, Mt. Stong features one of the highest waterfalls in Southeast Asia i.e. the Jelawang Falls where from a height of 590 m (1 500 ft) the water falls onto a seven-tiered cascade. Other places of interests include the crystal clear water at the rapids of Lata Chenai and Jeram Renyok. Many new records of lower and higher plant and animal species were revealed in the 2003 Expedition and one new ginger species was discovered.

<<Figure 1. Location of Mt. Stong P.F.R >>

4. Capabilities and technological features of UPM-APSB's airborne hyperspectral imaging system kit

UPM-APSB'S AISA is a state-of-the-art fixed-wing aircraft mounted commercial hyperspectral sensor developed and operated by Forest Geospatial Information & Survey Lab (FGISL)/Aeroscan Precision (M) Sdn Bhd. (APSB) in Lebuhr Silikon, Universiti Putra Malaysia. It is designed to provide near real-time, frequent, repetitive, accurate and reliable pushbroom instrument that acquire images in hundreds of registered, contiguous narrow spectral bandpasses such that for each element it is possible to derive a complete reflectance spectrum. The sensor is a complete system that consists of a compact hyperspectral sensor head, miniature GPS/INS sensor for precise positioning, data acquisition unit and special post-processing software (Figure 2). This small portable instrument, with a total weight of only 15 kg can be mounted on an aluminium metal plate that is compatible with a standard aerial camera mount, available in any fixed wing aircraft such as Cessna, Beechcraft, SkyVan and Nomad (Figure 3). Swath width is 360 pixels and field of view (FOV) in cross track direction 20° which makes ground resolution from 1 km altitude approximately 1 m at a flight speed of 120 knots (60 m/s). In addition, 20 pixels per swath for downwelling irradiance was acquired via a fiber optic irradiance sensor (FODIS).

Accurate position information, necessary for image rectification is measured with Systron C-MIGITS II integrated GPS/INS unit, which includes 3-axial inertial measurement unit based on solid-state gyros, GPS receiver and real time Kalman filter. Figure 3 illustrated the complete configuration system for the sensor kit. The effect of the aircraft such as the lateral roll is monitored using data from an onboard gyroscope. The advantage of this sensor over other hyperspectral instruments is the flexibility in selecting the sensor's spatial and spectral resolution characteristics. Reflected light from the target below the aircraft is transmitted through a sensor lens and directed to a prism-grating-prism optical system, which splits the light into its component wavelength spectra. The refractive properties of the two opposing prisms allow for a linear projection of light onto the CCD array. The two dimensional array consists of a spatial axis of 364 detectors, and a spectral axis of 288 detectors. It is capable of collecting data within a spectral range of 430 to 1 000 nm and up to 288 spectral channels within this range. Current operational collection configurations range from 20 to 70 spectral bands depending on the aircraft speed, altitude and mission goals.

The UPM-APSB's technology in question is based around an airborne digital push broom scanner operating in the visible/near-infrared range. UPM-APSB integrates the scanner (AISA) which uses on-board real time differential GPS for positioning and Precision INS for measuring and recording aircraft pitch, roll and yaw. This gives AeroMAP™ the ability to produce accurate base maps for State Forest Park development and management planning in Mt. Stong.

<<Figure 2: The UPM-APSB's AISA airborne hyperspectral imaging system kit>>

<<Figure 3: A complete airborne hyperspectral sensor mounted on-board a RMAF C402B aircraft >>

Resolution and accuracy of 0.5 m and above is achievable, and the base maps can be produced and draped over the digital terrain model. The advantages of airborne hyperspectral high resolution scanners and associated technology are flexibility and opportunistic deployment when ever required (i.e monitoring unpermitted logging) and measured information content more than a thousand times greater than satellite-based "observations". Most satellites have between three and five spectral bands; i.e, you can look at the forest in red, green or blue (RGB)-but the airborne kit has up to 288 spectral bands, so it is almost like flying a spectroradiometer in the sky. As such, the type of geospatial information which can be obtained from the images produced by this "bread-box" sized scanner, flown back and forth over areas of up to 600 ha; imaging 20 km strips of forested lands, can be characterized into two types: spectral and spatial information. The spectral information will allow for separation and identification of the differences in reflected radiation between surface objects. The spatial distribution of these objects and ground features allows for analyses in the spatial domain, such as identification of tree crowns of individual species, geological parent materials, etc.

UPM-APSB is looking forward to incorporate the airborne radar/ALSM/LIDAR, which is an imaging radar which should be able to fully penetrate forest canopies and achieve considerable ground penetration for biodiversity and geological measurement in deep mountain forests (Pope et al., 1994; Watt, 2005; and Wilson, 2005).

5. Best management practices (BMP) of Mt Stong Forest for sustainable development of a state forest park

The BMP of a mountain forest may be adopted from the elements and terms of reference in the Forest Management Plan (FMP) as outlined by Borhan and Dahlan (2006). Although, Mt. Stong State Forest Park is still in its infancy stage, the ultimate aim of the State Forest Department of Kelantan for the Forest Park is to be recognized as the best managed state forest park in the world. The Kelantan State Forestry Department vision recognizes the followings (Abdullah et al., 2006):

- (a) The Park is the cornerstone to conserve nature at the state level and probably in the future, be integrated at the state level and probably later be integrated as part of a national forest park system under the National Forestry Act 1984.
- (b) Th Park should ensure conservation of natural values for all time and for all peoples
- (c) Continuing engagement between people and parks, including enhance opportunities for all to visit, participate in, learn, respect, enjoy and preserve the Park as a fundamental purpose of management, and
- (d) The only use of the Park is nature-based and ecologically sustainable.

This vision can be made possible by establishing and managing with the involvement of interested stakeholders. Following this, a State Steering Committee for the Park headed by the Chief Minister will be established specifically to clearly state the vision, principles and aims for the Park future management. Subjected to a Five-Year Review, the Plan will be refined to ensure it remains a dynamic blueprint, responsive to emerging issues while providing a firm and clear overall direction, rolling into the future. Meanwhile, the Scientific Expedition in 2003 qualified Mt. Stong as a highly potential area for a state forest park due to certain qualities it possesses, which are as follows:

- (a) Comprehensive meaning that the Park covers a significant range of samples of regional ecosystems of the Peninsular
- (b) Adequate meaning that the Park is of a sufficient size to enable natural integrity, including the species diversity, of the park to be maintained; and

(c) Representative meaning that the samples of regional ecosystems include the maximum possible diversity of their plant and animals communities.

The Expedition only covered 800 ha or 3% of the Mt. Stong Park area and thus a large area still abound for further study. The rich natural assets of Mt. Stong Forest Park however need to be managed based on a world class system of management. In this respect, a long term Master Plan over a hundred years will be drawn up. This Master Plan will be reviewed every five years, with public participation to evaluate the progress towards the stated principles and aims, and to consider new issues and circumstances. In order to ensure the successful establishment of the Stong State Forest Park as the best managed park, three committees have been formed, namely, Steering, Management and Technical Committees. Kamaruzaman and Dahlan (2006) proposed that the management of the Park will be carried out by the Management Committee headed by the State Secretary, with the following roles:

- (a) Prepare an integrated management plan encompassing all the resources available for the Park
- (b) Review and reinforce the role of the Park through proper strategies and plans
- (c) Identify where systems and management need to be improved, and
- (d) Identify actions needed to achieve vision.

The daily administration and management of the Park will be carried out by the Technical Group headed by the State Forestry Department. At the two top-level committees formed, representatives from the political, state agencies, non-governmental organizations as well as interested groups, are committee members

In order to ensure the BMP of Mt. Stong forest resources as a State Forest Park, Dahlan and Abdullah (2006) identified four Park Management Plan Principles which must be adhered to as follows:

5.1 Protecting Stong Forest Park for Its natural heritage

Mt. Stong State Forest Park provides scenic backdrops of the Jelawang Falls; the rolling hills and the granite outcrops as tourist attractions. For many people who live away from nature, it gives a rare chance to experience the beauty and the sometimes harsh reality of the natural world. By protecting the diversity of landscapes, it provides the opportunity for people to connect with the forest and to experience and understand our natural heritage. For some people, quiet times in the Park can be a spiritual experience. The scenic landscapes represent the living history of our relationships with the forest. They are unique, irreplaceable parts of our identity, and provide opportunities for enjoyment, relaxation, recreation and education.

Principles: The Stong Forest Park will be permanently protected under the National Forestry Act 1984 and its natural integrity will be conserved under sustainable forest management, with its natural values protected and presented.

5.2 Working with local communities

Stong Forest Park can generate substantial economic benefits for the local communities where they can be trained to become guides or operate food and supply stores for visitors. As well as the direct income from tourism which they can bring, the Stong forest Park can provide vital “ecosystem services” to the community. For example, protecting watersheds provides relatively reliable water for agricultural and urban lands, erosion, and common effects of widespread land clearing. The large uncleared tracts of natural vegetation absorb greenhouse gases.

Principle: The Stong Forest Park will be managed in the context of surrounding landscapes with participation and involvement of local community needs and aspirations.

5.3 Sustaining recreational and tourism opportunities

For many people, Stong Forest Park can be a popular place to visit on weekends and holidays – to camp, picnic, hike, climb, enjoy a change of scenery, view wildlife or have a good time outside with family or friends. While facilities for camping and picnicking were planned here, the emphasis is on low-key recreation in the natural environment, where people enjoy themselves in simple ways without lots of development or artificial activities.

Principles: Opportunities will be provided for people to visit, participate in, learn about, respect, enjoy, preserve and protect the Stong Forest Park’s natural heritage. The Park will be managed to provide substantial and sustainable environmental, social and economic benefits to the local communities and the people of Kelantan while maintaining the intrinsic values of the Park. It will be managed to provide visitors with safe facilities and with information that will promote visitors awareness of the hazards present and the levels of skill and competence required to cope with the risks they may face.

5.4 Enhancing State Forest Department management capabilities

The previous three sections have dealt with particular aspects of protecting and presenting Stong Forest Park. The final section of the proposed Plan realizes that its human resources and the management can become progressively more skilful by raising the professionalism of the workforce, by better involving the skills, knowledge and industry and by using

progressively better information bases. The management can be more effective by supporting the workforce with trust, encouragement and adequate resources, and by developing and implementing good partnerships, policies and planning systems. In addition, it can be adaptive by becoming an innovative organization which learns through experience and is willing to try new ideas to be at the forefront of park management. The management of the State Forest Department will be more efficient by careful use of resources, delegation of responsibility to local levels wherever possible, communicating well and sharing information both within the agency and with other organizations. The principles of park management within sustainable forest management must ensure to remain as core factors in all decisions and activities. Stong Forest Park requires decisions at many levels. Planning and policy developments are effective mechanisms to gather information, to identify and integrate management decisions, and to transparently document a firm course of action. A high level of cooperation with other government agencies, including local government, is essential in many aspects of park management and may be defined in relevant plans.

Principles: The Stong forest Park will be planned and managed skillfully, effectively, adaptively and efficiently to maintain park values. Good management decisions will be made based on high standards of information and wisdom and community involvement in decision making. A dedicated, skilled and motivated workforce will manage the Park, using clear policies, directions and standards. Continual improvement in park management will be fostered through evaluation, learning, and reliable and logical allocation of resources.

6. UPM-APSB'S airborne system kit as a powerful tool for managing mountain forest resources

The UPM-APSB's technology in question is based around an airborne digital push broom scanner operating in the visible/near-infrared range. UPM-APSB integrates the scanner (AISA) which uses on-board near real time differential GPS for positioning and Precision INS for measuring and recording aircraft pitch, roll and yaw. This gives AeroMAP™ the ability to produce accurate base maps for State Forest Park development and management planning in Mt. Stong.

6.1 Current timber volumes per stratified hectare by crown diameter

With UPM-APSB's AISA airborne VIS/NIR scanner data alone, it is not possible to determine timber volumes directly, which is what an imaging radar can do (Strahler and Jupp, 1990). With the UPM-APB's AISA-type instruments, however it is possible to do important measurements in this regard. Assessment of crown size and identification of most likely species are possible. If this data is combined with ground derived models that relate crown size to tree height and diameter or tree size (allometric relationships) for the various individual species in the area, it would be possible to derive the average tree size, height and hence standing timber volume per hectare (Table 3). Hopefully, with the imaging profiling radar to be incorporated, we can directly measure forest height as well as general (ground) topography in the area of interest. At very high spatial resolution of AeroMAP™ AISA sensor (1m pixels), it would be possible to develop necessary software for use in counting the number of tree crowns and timber volume in a given area under study.

<<Table 3. Tree species counts and timber volume estimates in Mt. Stong P.F.R>>

6.2 Individual Species Identification and Mapping

Species identification is only possible with the UPM-APSB's AISA if a spectral library for all the likely tree species in the area is available, and at the same time, if there are sufficient spectral differences among species for the differentiation process. With the UPM-APSB's AISA, we have an advantage over all other technologies for this to succeed since spectral library profiles of more than 100 dipterocarp and non-dipterocarp species have been developed (Figure 4). We can airborne at high enough resolution to obtain spectrally 'pure' pixels for the crowns of the species to be identified, and in addition, the UPM-APSB's AISA is a calibrated spectroradiometer with high enough signal-noise ratio to be able to detect very small differences between spectra, if there are any. Figure 5 shows the image species identification and classification map of Mt. Stong based on an individual *Meranti Seraya* spatial distribution for field tree marking purposes. Higher classification accuracies are possible, if the UPM-APSB data is combined with data from other instruments like multi-band radar or other ecological information such as topography, meteorology, soil, etc.

<<Figure 4. Some selected image spectral signature library of species in Mt. Stong>>

<< Figure 5. An individual *Meranti Seraya* distribution map for tree tagging purposes>>

6.3 Forest features of special interest

The only quality parameters we can confidently measure in an undisturbed virgin mountain forest with the airborne sensor are turbidity and chlorophyll content. However, in this area, small streams and rivers are overshadowed by the dense forest canopies at most time. Pixel sizes in the UPM-APSB's AISA data need to be small enough (less than 1 m) to be able for use in smaller forest streams that are visible from the air. However, most of the clear unpolluted rivers and other features of interests can be easily mapped and quantified from the image as shown in Figures 6a -6b and 7a-7b.

<<Figure 6a. The unpolluted clear flowing Rantai river distributaries mapped in Mt. Stong P.F.R>>

<<Figure 6b. The beautiful Mt. Stong waterfall for swimming and picnic site>>

<<Figure 7a. Possible development of mountaineering and rock climbing activities in one of the steep rocky mountain Mt. Stong P.F.R>>

<<Figure 7b. One of the magnificent limestone caves “Gua Bogo” suitable for scientific expedition and eco-tourist attraction>>

6.4 Existing Logging Road/Skid Trails Impacts on Forest

Due to the potential for mapping land-use/cover, bare soil and different vegetation types with UPM-APSB airborne sensor, it becomes more a GIS task to map the effects of different logging and forest road activities on the forest. UPM-APSB's airborne data can then discriminate (and hence map into a GIS) road/skid trails types, locations, widths, buffers, etc. The current existing forest roads/walking trails buffers in the area can be easily and precisely mapped and inputted into a GIS format as shown in Figure 8.

Retention of information to compare future measurements with present mapping (change detection) is possible. One of the key features of this system technology is that it is based on a calibrated instrument and includes algorithms for physically-based atmospheric correction. This result in images scaled in terms of 'true reflectance', which is really the only type of remotely airborne sensed data, which can truly be used for change and detection mapping of features suitable for a state forest park planning and development.

<<Figure 8. The forest road buffers overlays with walking trails and rivers in the GIS format for potential state forest park sites in Mt. Stong P.F.R>>

6.5 Timber salvage harvesting and utilization plans

Since information on precision forestry can be obtained in near “real time”, Timber Utilization Plans can be prepared on an annually basis. These specify the location of the proposed timber salvage harvesting and stand management operations (Figures 9a and 9b). Plans can be provided to key stakeholders for comment and should be available in Kelantan State Forest Department office and on the website. Opportunities will be provided for comment on proposals before plans are finalized. Future timber utilization will conform to the requirements of this Plan.

Coupe plans will be prepared for the timber salvage harvesting operation since matured big-sized timber trees such as *Meranti Bukit* can be easily located from the UPM-APSB airborne sensor (Figure 10). These specify the boundaries of the harvesting coupe, harvesting standards, habitat tree retention requirements and any other management requirements. Coupe plans should be supported by The Malaysian Timber Harvesting Procedures which detail environmental and operational requirements for commercial harvesting. They are binding for logging contractors and provide the basis for the application of The FAO Timber Harvesting Guidelines.

<<Figure 9a. An individual species classification map of *Meranti Seraya* showing their precise location of “big-sized” trees greater than 103 cm DBH mapped in Mt. Stong F.R>>

<<Figure 9b. An estimated 40 years-old *Meranti Seraya* discovered from UPM-APSB sensor>>

<<Figure 10. The lower buttress portion of one of the biggest *Meranti Bukit* mapped in Mt. Stong F.R proposed for future timber salvage harvesting>>

6.6 Forest management prescriptions and zoning

Being most data on the Mt. Stong State Forest Park can be made available in near real time in a GIS format and image maps, the management prescriptions can provide detailed information and standards for the conduct of timber salvage harvesting and other State Park forest management operations. The Prescriptions and Zoning will be developed in consultation with experts in disciplines such as forestry, forest engineering, economy, botany, wildlife biology, ecology, watershed catchments management, water resources, cultural heritage and recreation/eco-tourism planning. It is expected that zoning such as Special Protection Zone, Special Management Zone and General Management Zone comprising of biodiversity conservation, water management, forest protection, forest production, recreation and eco-tourism, cultural heritage sites will be established and prescribed on the image maps.

7. Conclusion

The core of this paper is to provide useful information of airborne spectrometry using UPM=APSB hyperspectral imaging technologies to guide policy development in managing mountain forest in G. Stong F.R. The capability of AeroMAP™ to produce reliable and accurate resource measurements and maps indicated that it can provide a new force in the management and planning of tropical mountain forests, especially that of G. Stong as a Kelantan's unique state forest park. With the existing natural features of interest identified, quantified and mapped by the UPM-APSB airborne hyperspectral sensor, including the mapping of precise location of “big-sized” trees and their volume estimates, the mountain forest in Mt Stong is a magnet for outdoor recreation and forest eco-tourist enthusiasts, blessed with natural places of great beauty that can draw millions of local residents, domestic and foreign eco-tourists each year. If well planned and managed, G. Stong Sate Forest Park should be able to contribute to the allure of Kelantan, not only do this

state forest park provides access to varied and often unique natural, historic and cultural experiences but it also protects, preserves and maintains a dwindling supply of natural resources for enjoyment today and preservation for our younger generation tomorrow.

It is highly recommended that G. Stong be managed into a state forest park and therefore requires a Comprehensive State Forest Park Master Plan blue print. This is to guide the development of a diverse, balanced, statewide forest eco-tourism and outdoor recreation system towards meeting current and future needs providing a comprehensive planning and implementation process. Therefore, a dynamic updated resource supply inventory geospatial database in GIS format is deemed necessary to provide the foundation for Mt. Stong's BMP implementation process. UPM-APSB airborne hyperspectral data which is a "ready-made" GIS, should be in a position to facilitate access to the required data, tools and support needed by the Kelantan State government especially her Forest Department to more effectively and efficiently perform tasks associated with Stong's mountain forest administration, natural communities, optimum boundaries and conceptual state forest park land use management zoning.

Acknowledgements

The authors would like to thank the Kelantan State Forestry Department, Kelantan state government and Aeroscan Precision (M) Sdn Bhd for the generous funding of this project especially in providing the field staff and aircraft, assisting in the digital image analysis and ground support team, respectively to make this project successful. The authors are also grateful to Y.Bhg. Dato' Hj. Dahlan Taha for providing useful information on the Kelantan's forest resources facts and figures and the principles governing the management of a mountain state forest park.

References

- Abdullah Sani Shafie, Kamaruzaman Jusoff and Dahlan Taha. (2006). State Park Development and Management Planning Using Airborne Hyperspectral Imaging System and GIS in Gunung Stong State Forest Park, Kelantan. Procs. Seminar on the Stong State Forest Park Management Plan "Towards the Best Managed State Park". Kamaruzaman Jusoff & Dahlan Taha (Eds). 20 March 2006. Jabatan Perhutanan Negeri Kelantan, Kota Bharu, Kelantan. Malaysia. Pp. 11-22.
- Borhan Mohd and Dahlan Taha. (2006). Management Planning For Gunung Stong State Forest Park, Kelantan, Malaysia: Some Considerations. Procs. Seminar on the Stong State Forest Park Management Plan "Towards the Best Managed State Park". Kamaruzaman Jusoff & Dahlan Taha (Eds). 20 March 2006. Jabatan Perhutanan Negeri Kelantan, Kota Bharu, Kelantan. Malaysia. Pp. 40-50.
- Dahlan Taha and Abdullah Sani Shafie. (2006). Gunung Stong State Forest Park-Towards the Best Managed State Park. Procs. Seminar on the Stong State Forest Park Management Plan "Towards the Best Managed State Park". Kamaruzaman Jusoff and Dahlan Taha (Eds). 20 March 2006. Jabatan Perhutanan Negeri Kelantan, Kota Bharu, Kelantan. Malaysia. Pp. 1-10.
- Kamaruzaman Jusoff and Dahlan Taha. (2006). Pre-liminary Findings of Airborne Hyperspectral Imaging System For Gunung Stong State Forest Park Planning and Development. Dahlan and Abdullah, 2006. Procs. Seminar on the Stong State Forest Park Management Plan "Towards the Best Managed State Park". Kamaruzaman Jusoff & Dahlan Taha (Eds). 20 March 2006. Jabatan Perhutanan Negeri Kelantan, Kota Bharu, Kelantan. Malaysia. Pp. 23-29.
- Pope, K.O, Ray-Benayas, J.M and Paris, J. (1994). Radar remote sensing of forest and wetland ecosystems in the Central American tropics. *Remote Sensing of Environment*, 48:205-219.
- Strahler, A.H and Jupp, D.L.B. (1990) Modelling bi-directional reflectance of forests and woodland using Boolean models and geometric optics. *Remote Sensing of Environment*, 34:153-16
- Watt, P. (2005). Segmentation of yield class. Abstract. Forest Safe/Forestsat. June 2005. Information sheet distributed at XXII IUFRO World Congress, 8-12 August 2005, Brisbane, Queensland, Australia.
- Wilson, J. (2005). Production statistics from LIDAR and Aerial Data. Forest Safe/Forestsat. June 2005. Information sheet distributed at XXII IUFRO World Congress, 8-12 August 2005, Brisbane, Queensland, Australia.

Table 1. Land Status In Kelantan

No.	Status	Acreage (ha)	Percentage (%)
1.	Total land area	1,493,181	-
2.	Permanent Forest Reserves	629,687	43.2
3.	Wildlife Reserve	108,783	7.3
4.	State land Forest	155,801	10.4
5.	Alienated land	598,910	40.1

Table 2. Forest Classification In Kelantan

No.	Kelantan Forest Classes	Acreage (ha)
1	Production Forest	551,005
2	Water Catchments	41,924
3	Virgin Jungle Reserves	3,444
4	Recreation	5,057
5	Education	4,150
6	Research	2,157
7	State Forest Park	21,950
	TOTAL	629,687

Table 3. Tree species counts and timber volume estimates in Mt. Stong P.F.R

No	Name Species	of DBH < 55 cm	55 cm ≤ DBH ≤ 60 cm	DBH > 60 cm	Total No. of Species	Timber volume, m ³
1	pulai	0	0	944	944	5,352
2	keruing	3,068	0	0	3,068	7,793
3	jelutong	0	0	3,530	3,530	12,813
4	mt nemesu	3,205	0	0	3,205	9,935
5	mata ulat	3,585	0	0	3,585	4,051
6	kayu arang	2,726	2,725	0	5,451	3,598
7	kempas	6,114	0	0	6,114	8,988
8	putat	4,008	0	0	4,008	2,766
9	resak	5,907	0	0	5,907	3,190
10	penarahan	5,223	0	0	5,223	3,734
11	mempening	5,263	0	479	5,742	5,317
12	mt tembaga	2,259	0	2,260	4,519	12,988
13	mt seraya	2,647	548	4,472	7,667	26,604
14	nyatoh	5,671	1,134	1,418	8,223	11,101
15	mengkulang	4,291	0	1,431	5,722	6,581
16	medang	5,517	591	197	6,305	9,388
17	tempinis	4,551	0	0	4,551	5,507
18	minyak berok	11,159	1,395	0	12,554	34,899
19	rengas	5,534	0	0	5,534	6,032
20	kelat	3,172	378	680	4,230	5,795
21	merpauh	1,338	1,783	3,121	6,242	33,687
22	damar hitam	2,079	0	2,079	4,158	5,156
23	mersawa	4,138	0	690	4,828	3,211
24	kedondong	2,849	0	950	3,799	3,217
25	bintangor	3,175	0	0	3,175	2,014
26	kembang semangkok	2,752	1,376	0	4,128	21,012
27	durian	2,821	1,410	0	4,231	3,342
28	mt paan	1,758	1,759	0	3,517	4,080
29	membuluh	2,926	0	0	2,926	2,458
TOTAL		107,738	13,099	22,251	143,087	264,609

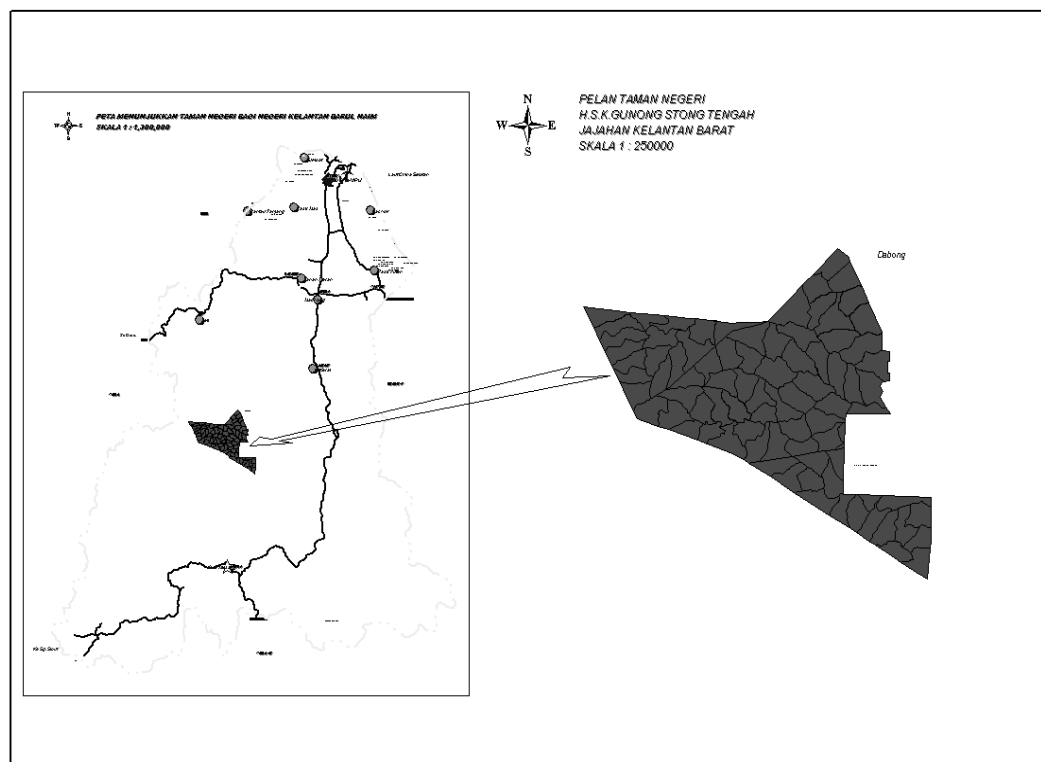


Figure 1. Location of Mt. Stong P.F.R



Figure 2. The UPM-APSB's AISA airborne hyperspectral imaging system kit



Figure 3. A complete airborne hyperspectral sensor mounted on-board a RMAF C402B aircraft

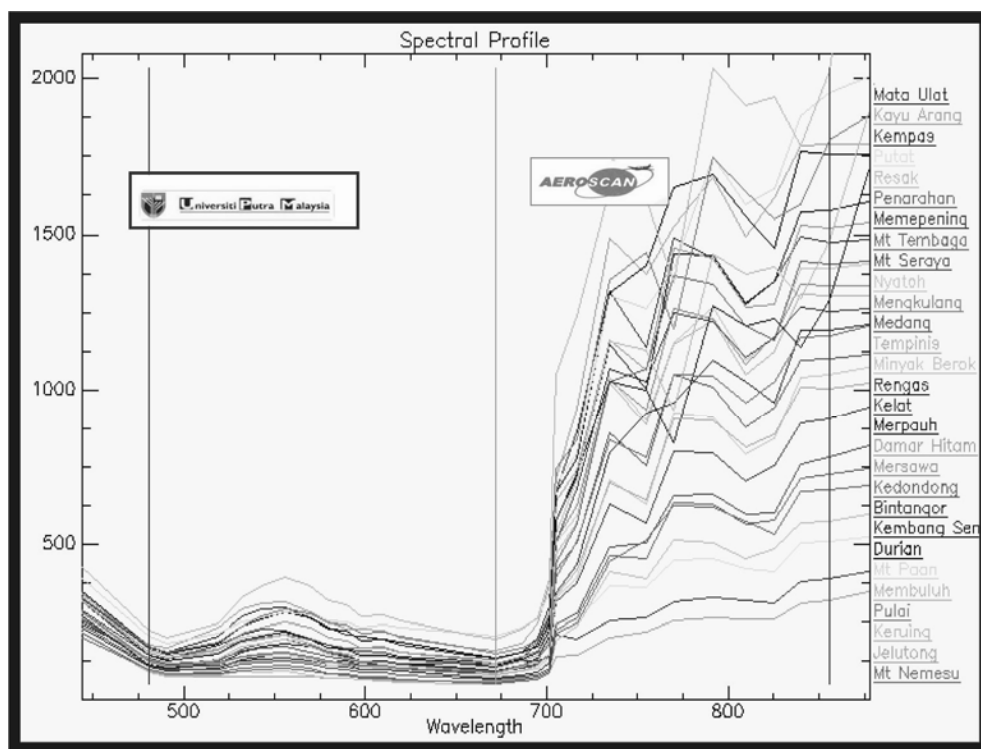


Figure 4. Some selected image spectral signature library of species in Mt.Stong

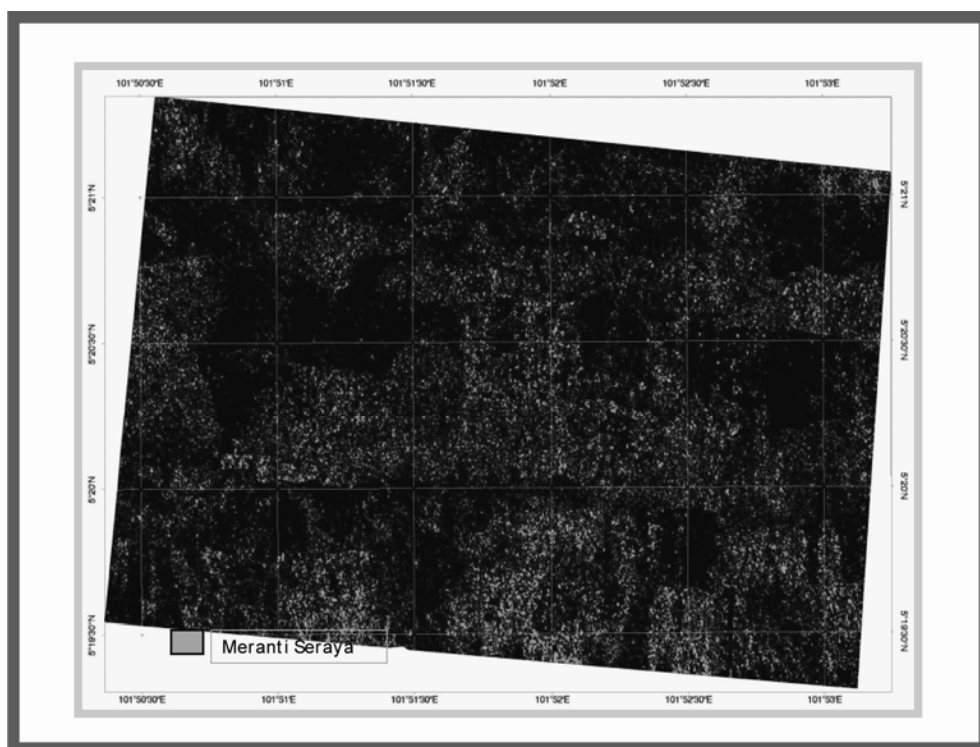


Figure 5. An individual *Meranti Seraya* distribution map for tree tagging purposes

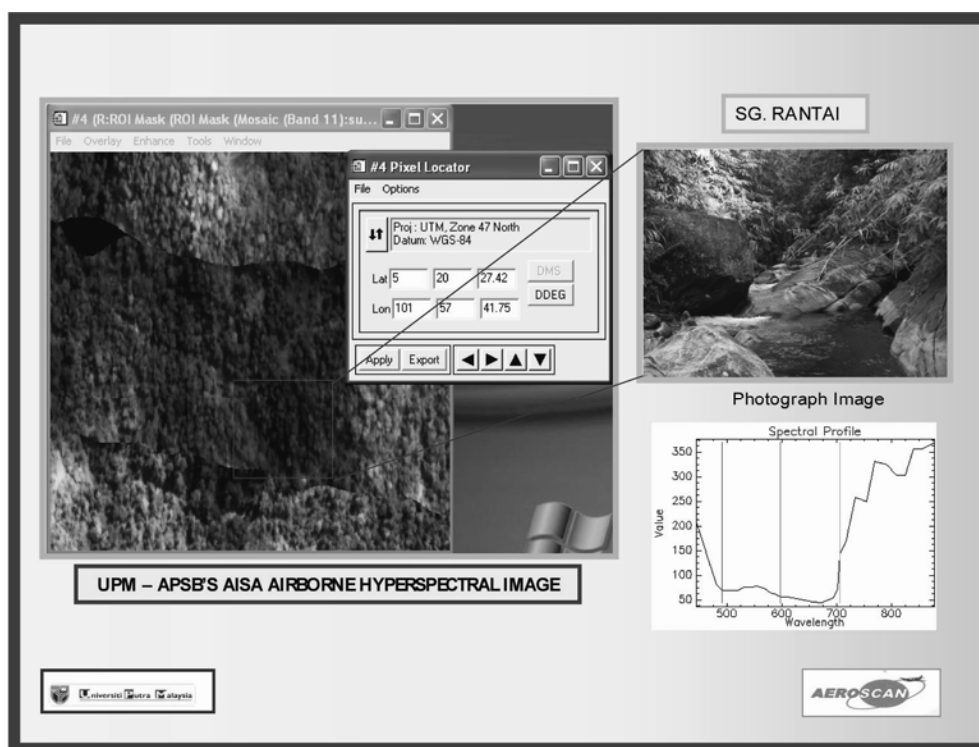


Figure 6a. The unpolluted clear flowing Rantai river distributaries mapped in Mt.Stong P.F.R

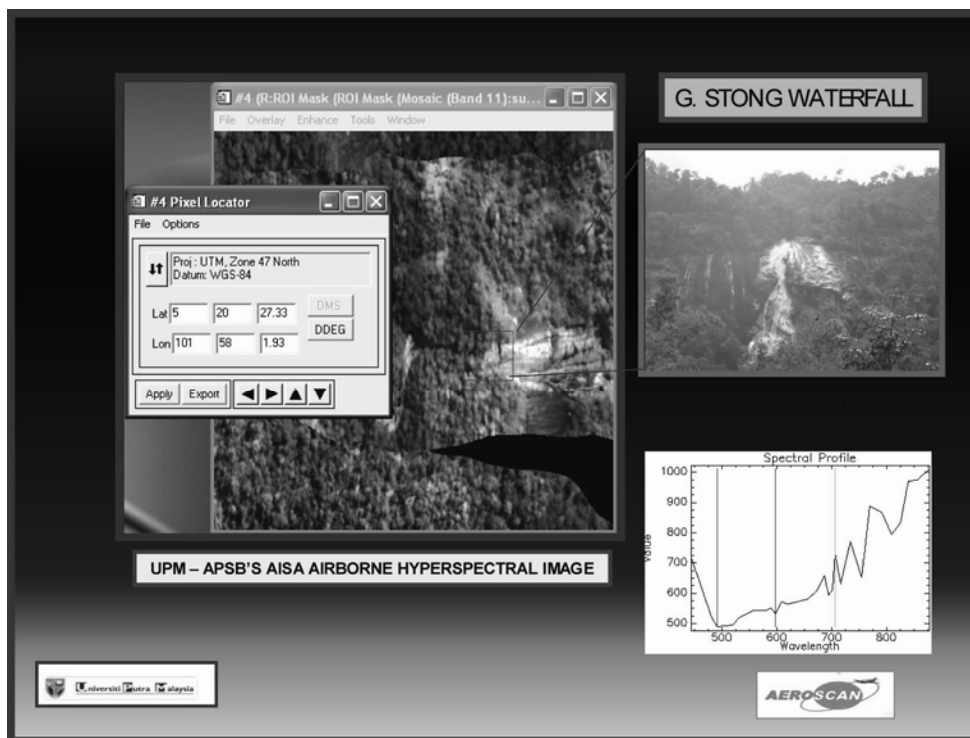


Figure 6b. The beautiful Mt. Stong waterfall for swimming and picnic site

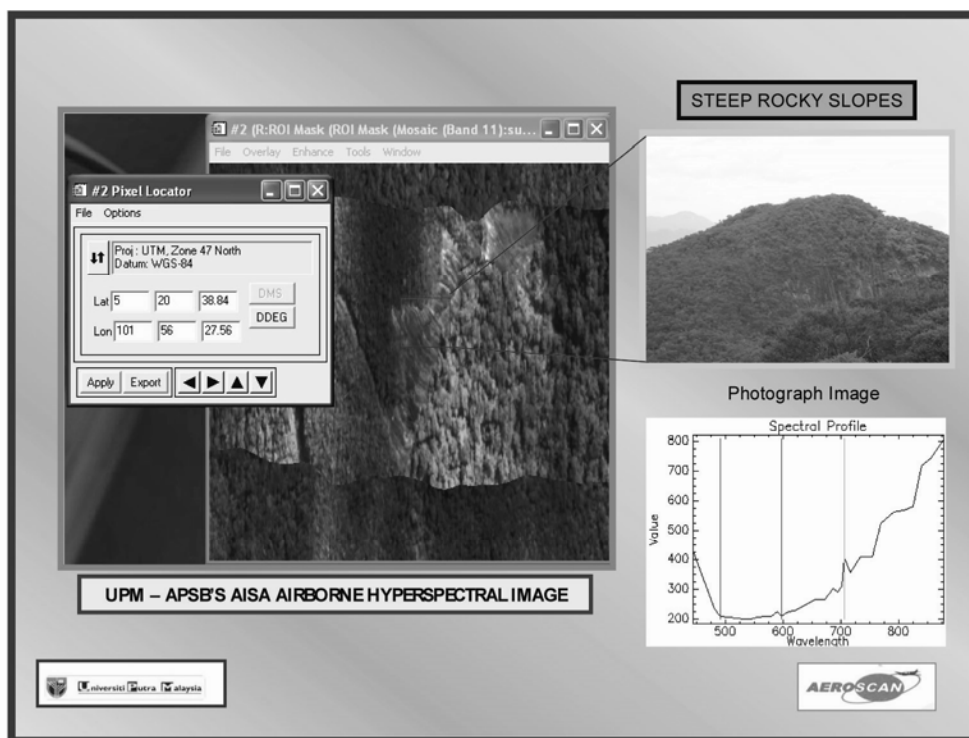


Figure 7a. Possible development of mountaineering and rock climbing activities in one of the steep rocky mountain Mt. Stong P.F.R

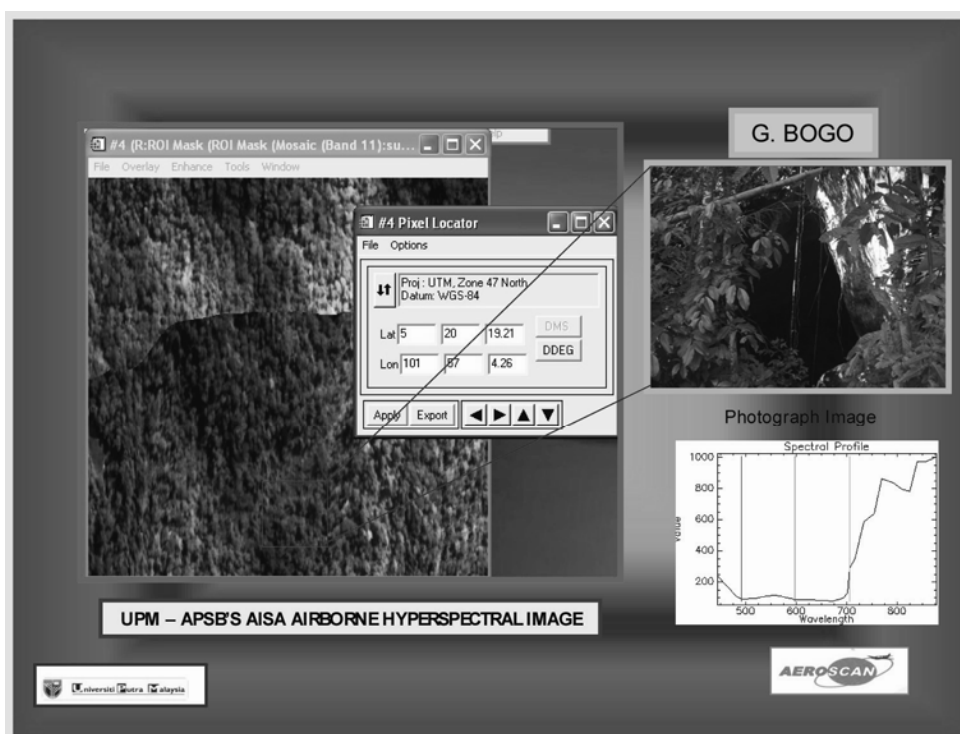


Figure 7b. One of the magnificent limestone caves “Gua Bogo” suitable for scientific expedition and eco-tourist attraction

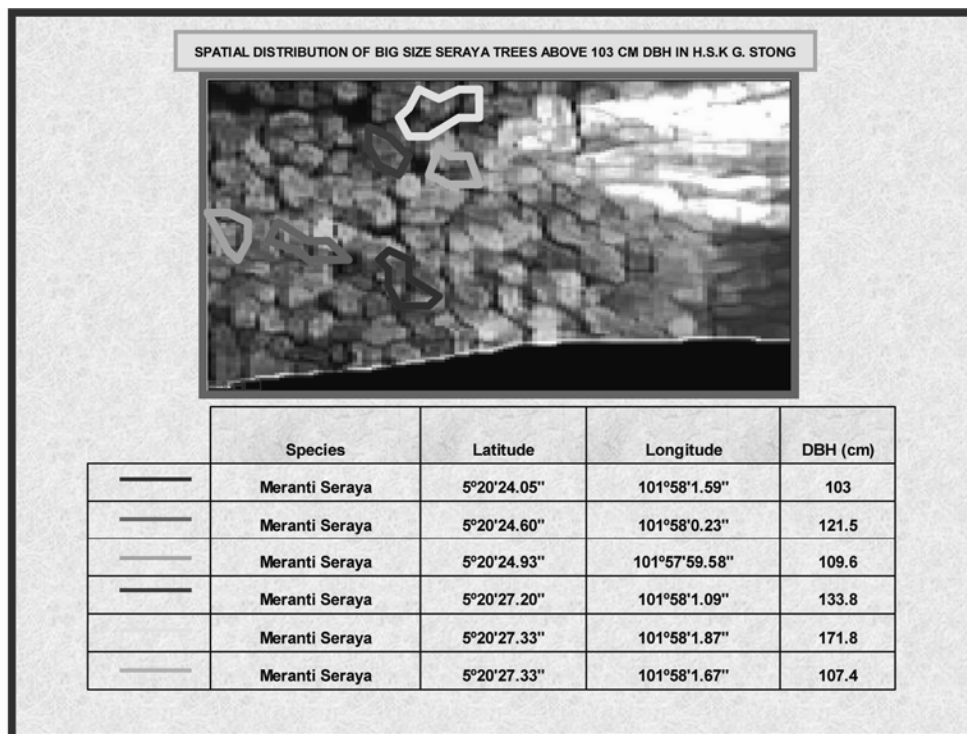


Figure 9a. An individual species classification map of *Meranti Seraya* showing their precise location of “big-sized” trees greater than 103 cm DBH mapped in Mt. Stong F.R

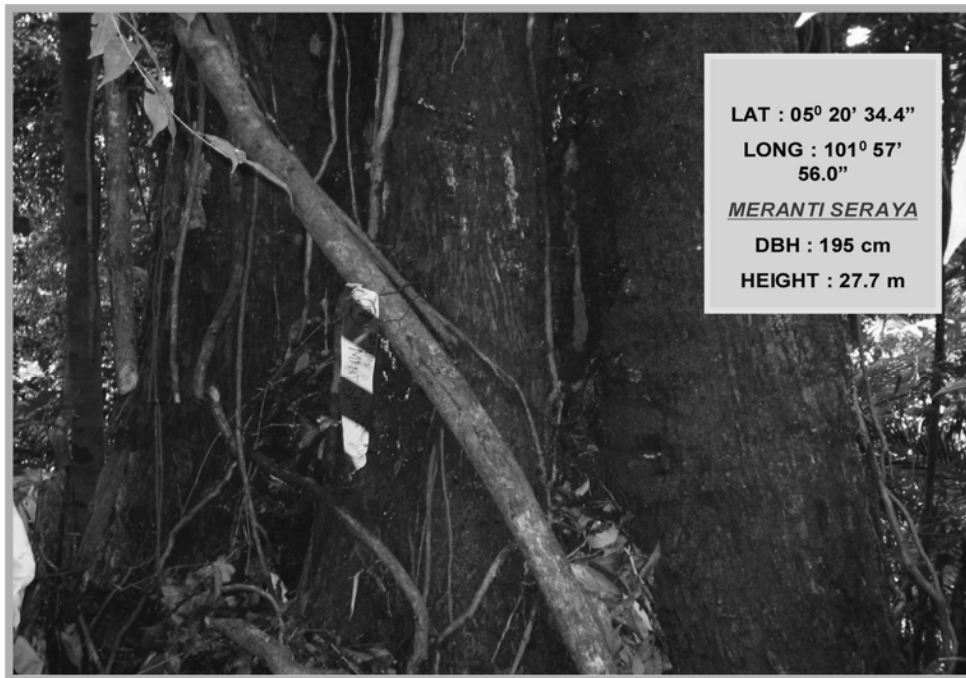


Figure 9b. An estimated 40 years-old *Meranti Seraya* discovered and mapped from UPM-APSB sensor

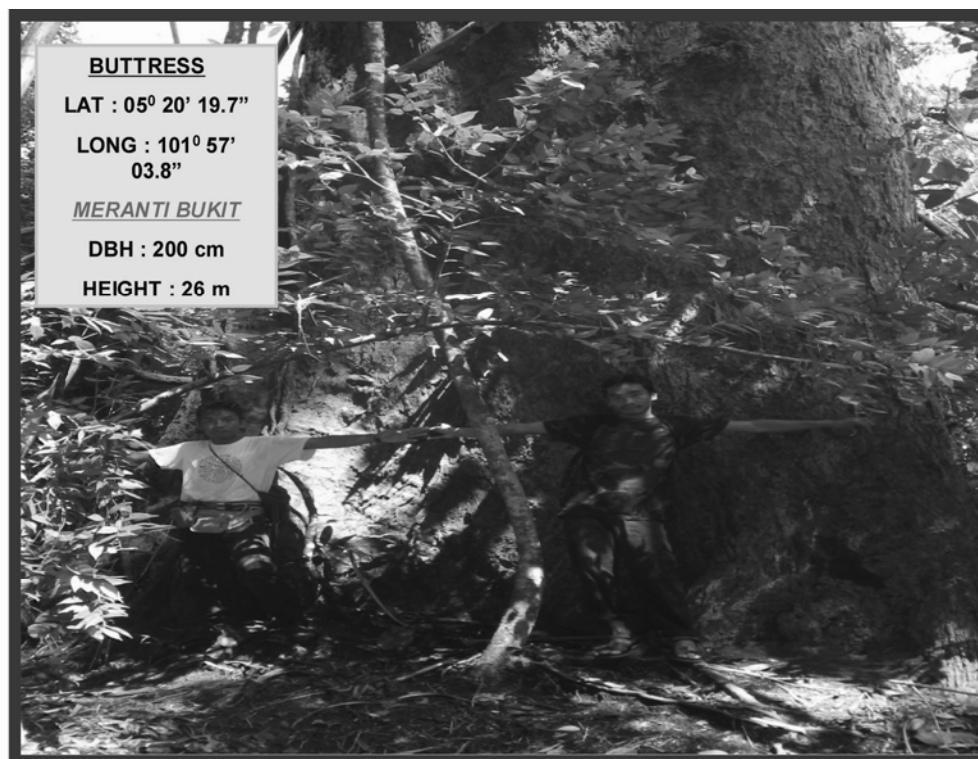


Figure 10. The lower buttress portion of one of the biggest *Meranti Bukit* mapped in Mt. Stong F.R proposed for future timber salvage harvesting



Study on the Case Teaching Method and the Sustainable Development Education for the Inner Mongol Colleges

Qingguo Meng

School of Education

Huazhong University of Science and Technology

Wuhan 430074, China

Youth College of Political Science of Inner Mongolia Normal University

Hohhot 010051, China

The research is financed by the Inner Mongolia Sustainable Development Management Factors Research in the 2005 Social Science Plan of Inner Mongolia Autonomous Region (No.0521). (Sponsoring information)

Abstract

Based on the case, this article expatiated on the criticalness, the transformation and the practicalness of the sustainable development education. Through the development research of the Inner Mongol cases, we pointed out the case method of teaching was a sort of teaching mode with significant efficiency to realize the multiple objects of the sustainable development education for the Inner Mongol colleges, put forward the objective system and the tenet of the sustainable development education which was the remodeling of the emotion and the value view to promote the establishment of the core idea of the sustainable development education.

Keywords: Education for sustainable development, Intergenerational equity, Criticalness, Case method of teaching, Transformation

The sustainable development education is the education for the sustainable development, and it is first the sustainable development of the education, and it is different with the unilateral and oriented environment education and development education. The sustainable development education is the learning process with a view to the economy, ecology, justice and future of the society, and in this process, learners can study how to make decisions, and the core task of the sustainable development education is to establish the thinking ability oriented towards the future.

At present, the sustainable development education of China is still on the start level, and the establishment of the college environment courses basically aims at the specialty. According to the statistics, only about 10% colleges in Chinese colleges set up the courses about the environment science, but the real trans-subjects sustainable development courses are still on the start level in individual colleges, and the practice and the research about the teaching method, teaching material development and teachers training are almost blank. The sustainable development education of Inner Mongol colleges is still in the stage of theoretical introduction and practical exploration.

According to the macro theoretic characteristic of the sustainable development, under the influence of traditional teaching mode, the teaching aiming at this concept or knowledge system easily becomes formalistic theoretic and knowledge infusion and concept deduction, but as viewed from the micro aspect, the sustainable development more emphasizes the active participations of local and community citizens, and makes it develop as the practice subject studying something in order to apply it. Many characteristics of the case teaching method fulfill the special demands of the sustainable development education, and offer a breakthrough for the promotion of the sustainable development education. In addition, its flexible and innovational characters indicate the direction for the practice and the enhancement of the teaching material compiling and quality education.

The case teaching method is a sort of teaching method which the teaching party and the studying party directly participate in and discuss the case or difficult questions and cultivate learners' practical application ability. And it can retrospect to the time of ancient Greece, and Socrates adopted the teaching methods such as the dialog mode, the discussion method, the heuristic mode of teaching in his teaching process, and emphasized to cultivate students' independent thinking ability, suspicious and critical spirit, and his teaching method was very important to form the western education and the academic tradition. Therefore, the case teaching method is also called as the "Socratic

method”, and it is the main teaching method in the law schools of the Anglo-American legal system, and it is also extended in the commercial colleges. The practices indicated that the case teaching method could be successfully applied and pushed in the sustainable development.

Inner Mongol Autonomous Region transverses northeast, north China and northwest of China, and most regions are located in the sensitive belt of the global change, and the ecological environment is frangible. According to Chinese sustainable development strategic report (2006) by the Chinese Academy of Sciences Sustainable Development Research Group, in the Region, the comprehensive performance index of the resource environment was 144.4, and it ranked in the 26th, and the science and technology strength ranked in 26th, and the total ability of the regional sustainable development ranked in 23rd. The mine resource exploitation and smelting belonged to the industry with high energy consumption and high pollution in the heavy industry, and it largely influences the ecological environment. For the environment and the development, the total ability of the science and the sustainable development are core factors, and the Inner Mongol sustainable development will be seriously restricted by the subjective conditions and the objective conditions in the present special transformation stage.

Aiming at above actualities, the introduction of the educational variable will exert long-term and important function to the sustainability of the local development, and the introduction of the sustainable development education in the higher education system is the innovational action in the existing course mode, and as viewed from the long term, the exploring thinking of the educational reform may be the important factor to push this sort of transformation.

The sustainable development education possesses many new characteristics different with traditional education mode, and it requires a sort of new view to study and explore the education. In this article, we try to explain and break through the sustainable development education from environment practice and the teaching case of Inner Mongolia.

1. The case teaching must accord with the objective frame of the sustainable development education for Inner Mongol colleges

1.1 The target of the sustainable development education for Inner Mongol colleges

As the main field to cultivate the middle and super talents, colleges are very important to push the sustainable development education, and aiming at the problem how to change the actuality of the sustainable development education to the concept and practice popularized by the society, the education constitution must put forward and concretize the target of the sustainable development education.

The undeveloped Inner Mongol region urgently needs the talents with the reform idea and the sustainable development concept to lead the implementation of the local sustainable development strategy. The important task of Inner Mongol colleges is to cultivate the value view, behavior and living mode according with above ideas and concepts, so the target of the sustainable development education can be divided into four dimensions such as knowledge, thinking, culture and responsibility (seen in Figure 1).

Four dimensional targets A, B, C and D escalate from A to D, and D is the highest target which is to form learner's responsibility for the biological environment and promote the implementation of the sustainable development concept. Target A emphasizes the individual sensitivity and comprehensive cognition to the environment, and popularizes the diffusion of the knowledge in the whole society, and forms the significant characteristics different with other knowledge structures. For example, the concept of the ecological footprint is sort of special index to measure the sustainable development. The system thinking of the Target B is the necessary ability factor contained by the sustainable development education, and it requires taking the sustainable development as a changeable process, and continually putting forward the optimal project of the optimal solution according with the dynamic development. Target C takes up with the optimal integration of multiple national cultures and avoids losing the justice and benefits of the next generation in the process of the cultural integration.

In the multiple-objective frame, the cultivation of the communication skills and the formation of the systematical thinking are orientated on the human resource with potential management ability, so the excellent talents will show themselves and become the leading power in the local transformation development.

1.2 The homogeneity of the case teaching method and the sustainable development education largely increases the possibility of the extension in the sustainable development education process and ensures it can accord with the target frame system to the largest extent

The sustainable development education is significantly different with the traditional education, and it emphasizes the establishment and the practice of many value views such as balance, justice, fair, harmony and political consultation, and the education receivers should be the transformation factor in certain region or the society. In addition, it is also a sort of education of introspectiveness and criticalness, and it encourages animadverting on the social current malpractice and the traditional idea and emphasizes the cultivation of the reform ability.

The sustainable development course includes abundant case resources, and the cases in different regions are not only

different but also representative. For the global background, the concept is one of the biggest cases.

As a sort of teaching method emphasizing the practice and ability, the case teaching method can lead students to analyze, judge and make decision independently, break through the restriction of the traditional teaching method, and promote the behavior transformation of the teaching and studying in the democratic participation, and transform from traditional teacher-oriented to the students' active participation. Sorts of characteristics of the case teaching method accord with the sustainable development education, and the homogeneity of both method ensures this sort of teaching method can more flexibly serve for the target of the sustainable development education (seen in Table 1).

2. The selection and development of the case should accord with the actuality and the requirement of the Inner Mongol sustainable development education

The selection of the Inner Mongol sustainable development case should give priority to local classic real examples, and the design and the development of the case should combine with local situation. According to the humanistic, ecological environment and resource characters of Inner Mongolia, we should search, process and re-create the original materials, and realize the multiple-subject character and the science character of the information. The following case is the real example of the Inner Mongolia.

[The historical variance case of the certain village in Inner Mongolia]

The village was a rangeland with abundant grasses and trees, and it includes three natural villages. In the middle and late of 1980s, the village was in the peak period of the planned economy, and the amount of livestock on hand achieved 63000, and the Han national population was 1730, and the Mongol amount was about 800, and the land area achieved about 1300 square kilometers, and the south of the Sumu government had the forest with about 8 million square meters with poplar tree, elm and desert dates, the traditional Mongol Nadam Fair every year, cultural and artistic performances, and many competitive activities such as horse race, tumbling and toxophily. In the late of 1980s, with the deepening of economic reform and the opening of the livestock feed, and in the 1990s, the amount of shepherd had exceeded ten thousands.

[a. The introduction of the governmental background knowledge]

In the term of planned economy, most administrative cadres and technical cadres were junior college or technical secondary school graduates, and they possessed quite abundant special knowledge about the farming medicine. According to the professional measurement, the livestock quantity in every square kilometer was 1 to 2 sheep. And the village uniformly managed the livestock, and it was conformed as the cultivation base of the half fine wool sheep. Through many ecological-protective measures such as stable breeding, amount limitation, base establishment of grain feeds and green feeds, the stock raising realized virtuous circle.

Problems:

- 1) In which aspects, the government can promote the protection and optimization of the ecological environment? Is that only the responsibility of the government?
- 2) In the tendency of the present public management marketization, how the governments do to protect the environment?

[b. The integration of national cultures]

Since 1970s, large numbers of Han people continually transferred to this place, and they developed a piece of land in the southeast of the forest to plant the food supplies and vegetables, and Mongol people begun to eat more wheaten foods and vegetables and Han people ate more meat products. After 1980s, the government begun to run the school, and there were about 400 students and more than 50 teachers and the Mongol school. However, more and more Mongol students begun to study Chinese language, and the Nadam Fair in every year was stopped.

Problems: What are the advantages and disadvantages of the national cultural integration? Which factors can promote the disappearance of the cultural phenomena?

Profound problem: What are the core factor and the value view of the Mongol culture? What specialties are embodied in the culture? How can we inherit good cultural traditions and value views?

[c. The variances of the environment and the climate]

Before 1990s, there were one or two sand blown, and the sand earths were not more, and there were rains in the summer which would induce the flood, and there were heavy snows in the winter which was the view in each year. After that, the climate gradually became warm, and because of excessive reclamations and feedings, the grass field was deserted and the speed of the desertification was surprising. Many families were forced to migrate, and the grassland dried in successive years and there were almost no snows in the winter.

Problems: 1) Facing the global phenomena of climate change, whether the human being are only waiting to accept?

What revelation does the sustainable development on the regional layer offer?

2) As one of main reasons of the environment depravation, how we recollect the value view of the traditional people-orientation? What values does the environment embody?

[d. The development of the commercial economy]

The whole time of 1980s was the period which was the most flourishing term, and the population achieved about 3000. Since 1985, the family-contract responsibility system was introduced, and the development of the stockbreeding had entered into the unordered and free market extension period, and the livestock amount largely exceeded the load of the grassland. At the same time, the quick price increase of the mutton, beef, cashmere and wool brought up many "households with an annual income of 10,000 Yuan" on the grassland, and they possessed wind generators and jeeps. The economic development promoted the local traffic industry, and individual bright businessmen became the local wealthy households in several years. However, the damage of the grassland ecology got more herdsmen into the poor, and the double-polarization became more and more serious.

Entering into the 21st century, the geological exploration department found the coal resources of a hundred million tons, and the exploration plan of the enterprise is being implemented.

Problems: 1) In the economic reform, what functions should the government carry out to ensure the sustainable development of the economy?

2) Is the extension of the income difference positive proportional with the ecological depravation? How do we treat the problem of the poor?

3) How do the local citizens and government share the economic boom? Does the enterprise emphasize the long-term ecological benefits? How do the local citizens cultivate the non-governmental organizations to maintain their economic benefits and protect their own survival environment?

Simple analysis: This case is a real evolvement process of the field, and it comes down to various aspects of the core factors of the sustainable development, such as humanity, ecological environment, economy and technology, and though the technology wasn't put forward in the case, but the large-sized coal mine which would be mined will contain more technologies about clean production. According to different angles, the case can be divided into four sub-cases, i.e. case A, case B, case C and case D. Of course, aiming at the students with different professional backgrounds, we can further divide the sub-case. For the sub-case D, we can introduce some data such as cost, price and tax, and describe the management of the coal enterprises according to the practical situation of the existing coal mine, and we should put forward the evaluated problems or let students give the decision project aiming at management and environmental strategy and other problems.

3. The case teaching should combine with various methods to promote the teaching reform and the effect

The sustainable development faces various challenges which are occurring or will occur in the ideology or the real society, and it requires individuals or organization to adopt decisive actions to maintain the human dignity, i.e. the human dignity is the dignity equally shared by every individual without the differences of nation, country and race.

The education based on the sustainable development must face various challenges, and promote the anticipative actions and form justifiable, equal and harmonious value view. Therefore, the sustainable development education can adopt many methods such as character, arts, argument and experience to achieve the final target.

How can the case teaching method effectively serve for the objective system of the sustainable development education? What innovations should the case teaching method have? That are the topics what we should urgently solve.

As a sort of teaching mode to enlighten students to study the practical problems, emphasize students' intelligent development and ability cultivation, enhance the future-oriented comprehensive quality, the case teaching method can reform the sustainable development education and realize the maximization of the teaching effect with various forms.

3.1 The case of the activity mode

The case is developed by the activity mode, and the activity rules must be definite, and the teacher should be the organizer and the manager to ensure that the activity could inspire students' study motivations. Taking the sub-case D as the example, students can play different roles in the institutions such as coal bidding enterprise, government and green organization according to different occupations, and they are divided into many groups to simulate the real business operation process, and experience different roles' emotions and decisions. In the activity mode learning process, we can understand the meaning of the sustainable development and conclude effective measures.

3.2 The case of the exploring research mode

The sustainable development education should emphasize students' active exploitations and researches including direct experience. Teachers should appoint the research topics for students, organize students to experience the local

environment in the locale, obtain the first hand cases about the environment, humanity and economy through the environmental investigation, and analyze and study these cases.

Aiming at the deficient practice, analysis and comprehensive abilities for college students, the case teaching method can innovate in the close combination of the theory and the practice of the sustainable development education, and support capitals and academics for students' practice, exploitation and researches.

The BELL green demonstration course of the Environment College of Beijing Normal University adopts the teaching method combining with college teaching, professional lectures and speech, and puts forward legislation and policy advices through cultivating the team spirit by many modes. The course design is inclined to the case analysis, expert lecture and group discussion. The group which is composed by the students with different specialties can independently select the research topic in the discussion group appointed by the teachers, and the topic includes "the social responsibility of the industrial and commercial enterprise, the function of the civilian environment-protective team, the constitution of the South-to-North water diversion and the environment public policy", and the teaching methods include case study, lecture and interactive proseminar, and under the organization and the guidance of teachers, various groups will complete their own topics. The exploitation and innovation of the case teaching method in Beijing Normal University could obtain active effect, largely inspire students' participation and cooperation spirits, and the disadvantage is that the summarization and the enhancement of the research results are not enough, and the instruction function to the practice is deficient.

The extension of the BELL course and the similar training teaching items in Inner Mongol colleges are possible, and the trans-subject teaching reform of Beijing Normal University can be referred in the extension process of BELL course.

3.3 The case of the behavior experience mode

The sustainable development education should first exert the function in the optimization of the college environment. The colleges and relative research teaching institutions about the sustainable development should encourage students to actively participate in various stages such as the plan, the decision and the implementation of the college environment plant engineering. Students are the first eyewitnesses of the college environment, and they are urgent to change the environment. The interior problems in the colleges are the optimal cases such as the throwaway chopsticks, the food plastic bag and the green environment association.

Teachers should improve the occasion and assist students with potentials and behavior abilities to establish the non-government environment organizations rooting in college environment, college culture and college custom when diffusing the knowledge concept of the sustainable development, and organize case discussions aiming at characters, functions and strategic ideas of the non-profitable organization to deepen the knowledge, confirm the objective, select leading talent and form decisive action. In addition, the case teaching method can also combine many methods such as role playing and observation interview to cultivate the emotion, the attitude, the value view and the living mode of the sustainable development.

References

- Jiang, Dongmei. (2002). *The Environment Education Teaching Method and Its Application*. Beijing: China Environmental Science Press.
- Liu, Cangyan. (2004). Analysis of the Reasons that the Case Teaching Method Cannot be Pushed Favorably. *China Education*. No.6.
- Liu, Yigong. (2003). Socrates and the Case Teaching Method. [Online] Available: <http://www.xkcj.com>.
- Wang, Gaoquan. (2004). The Study and the Practice of the Geographical Case Teaching Method. [Online] Available: <http://www.doule.net>.
- Wangmin. (2002). *The Sustainable Development for Education*. Beijing: China Light Industry Press.

Table 1. The homogeneity of the case teaching method and the sustainable development education

Case teaching method	Sustainable development education
Associate the theory with the practice, take the objective, real and locale cases as the teaching materials to implement the theoretical discussion or form the new theoretical growth point through the discussion	Root in regional or community economy, society and ecology, fully recognize the existing crisis and participate in solving the crisis, integrate the learning experiences into daily individual or occupational living
Students change from passive knowledge accepters to the masters in the classroom, take learning as the principal thing, and the teaching is the assistant	Take the process not the result as the orientation. Emphasize the learning not the teaching, especially emphasize experienced learning and the democracy learning after transformation
Encourage students to freely explore and doubt, cultivate students' independent thinking ability and doubtable and critical spirits	Critical thinking, challenge for the main-stream idea and value view, allow to put forward different value view and new opinions
Emphasize the cultivation of the comprehensive quality, cultivate students' logic reasoning ability, research ability and communication and expression ability	Establish the thinking ability taking the system thinking, communication ability and management factor as the core
Students actively and independently think and research practical questions, enhance students' abilities to analyze and solve problems	Solving problem, increase the confidences to solve the conflicts and challenges in the sustainable development
Promote students to communicate and cooperate, respect and care about others through group discussion	Change only imparting knowledge to obtaining knowledge by teachers and students together, and the cooperation is also a core factor of the sustainable development
The balance of teaching and learning, the balance of objective facts and subjective evaluation, the balance of learners' different opinions and ideas	The balance includes the individual aspects such as the objective and the subjective, the sense and intuition, the material and spirit, and the whole aspects such as the economy and ecology, the present and future, and the individual and society

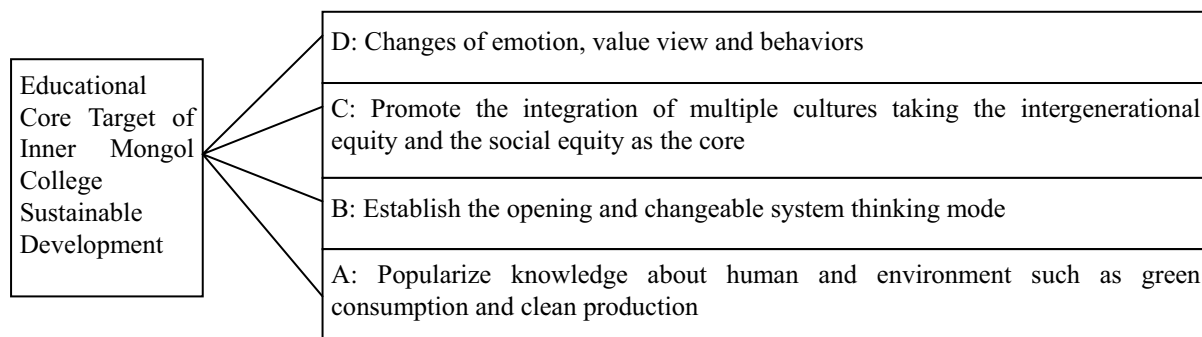


Figure 1. Four Dimensions of the Target of the Sustainable Development Education



Preparation and Characterization of Bio Fuel from Industrial Waste

M.N Abinayah Shree

Department of Chemical Engineering
ACT Campus, Anna University-Chennai
Chennai-600 025, India

K. Iyappan

Department of Chemical Engineering
Central Leather Research Institute
Adyar, Chennai-600 041, India

N. Balasubramaniam

School of Engineering
Monash University Sunway Campus
46150, Selangor Darul Ehsan, Malaysia
E-mail: n.balasubramanian@eng.monash.edu.my

C Srinivasakannan

School of Engineering
Monash University Sunway Campus
46150, Selangor Darul Ehsan, Malaysia

Abstract

Disposal of biomass becomes often an environmental issue. A novel method has been developed to convert biomass into solid bio-fuel. Experiments were carried out on preparation of solid fuel pellet from industrial biomass wastes. A maximum calorific value of 22,593KJ/kg has been obtained for the bio-fuel prepared in the present investigation and compared with the fossil fuel coal. The bio-fuel pellets were burnt and the emitted green house gases were critically analyzed.

Keywords: Bio-fuel, Solid waste, Coir pith, Sawdust, Colorific value

1. Introduction

Biomass can be converted into fuels through physical, chemical and biological conversion processes. Basically, the biomass has low energy, less density, bulking occupy large volume of space and difficult in transportation. Conversion biomass into fuel transforms the waste into a carbonaceous material, which may be a substitute for the conventional/fossil fuel. In fact the bio energy meets 14% of the total energy demand and the percentage will go up in the future. The biomass absorbs and emits carbon dioxide during growth combustion respectively and no contribution to the greenhouse effect. Some of the current biomass technologies are: gasification, pyrolysis, supercritical fluid extractions, liquefaction hydrolysis, biological conversion, conversion of biomass to a pyrolytic oil fuel (Olsson *et al.*, 1996; Alejandro *et al.*, 2007).

In recent year there has been increased interest among the researchers/industries to convert the industrial solid waste for effective utilization. Wood saw dust, sugar cane bagasse and leather waste are some of the biomass available in large quantities which are bulky and heterogeneous in nature. Several authors have attempted to convert the biomass into solid-fuel pellet for effective utilization. Among the biomass resources, the wood pellets become gained attraction for power generation and residential application. Conversion of wood waste into solid biomass fuel will have both

economic and environmental advantages (Palchonok *et al.*, 2002). Olsson *et al.*, (2007) analyzed the emissions from wood pellets from various sources and reported large differences in the emissions from pellets from different manufacturers. The other contributors on wood biomass are due to Ndiema *et al.*, (1998); Maria *et al.*, (2003); Catharina *et al.*, (2006); Fabienna *et.al.*, (2006). The objective of the present investigation is to convert biomass waste from coir pith and saw industries into potential solid bio-fuel and analyze their characteristics.

2. Experimental

Experiments were carried out on fuel pellet preparation from industrial waste under various compositions. Raw material such as sawdust of *Tectona grandis*, *Pterocarpus indicus* and coir pith were collected from nearby industries. The cleaned raw materials were kept in an oven at 110°C for overnight to remove the free moisture and then subjected for solar drying. Solid particles of 1.5mm were sieved from the powdered waste for the pellet preparation. The moisture content and calorific value of the processed raw materials were estimated. Neem gum was used as an additive for pellet preparation. The Table 1 shows the combinations raw materials chosen for pellet preparation. The samples were blended well in mortar and pestle then passed through a die. A high pressure of 10,000N/cm² was applied using mechanical press. The pellets obtained were again heated at 120°C for one hour to remove lignin and cellulose materials. The prepared pellets were subjected for calorific value, ash content and density. Approximately 10grams of sample was burned and the gas emitted during burning analyzed for green house gases and VOC.

3. Results and discussion

Table 2 gives the moisture content of raw material before and after the processing. It can be noticed from the table that the moisture content of the raw materials were decreased during the processing. This can be due to the fact that the raw materials tried to adjust with the relative humidity of its surroundings. A reduction in moisture content increases the mechanical strength of the raw materials and promotes hydrogen bridge cross-bonding between adjacent cellulose chains in regions of low spatial order which are primarily responsible for stiffness and rigidity.

The Table 3 shows the physical characteristic of solid pellets prepared in the present investigations. It can be noticed that the calorific values were increased from the raw material due to mechanical processing. Noticed that a maximum of 22593KJ/Kg⁻¹ with 27% increment for the mixing ratio of 1:1:1:3. It can be noticed further that the material density increased during processing. The analysis of gas emitted from the pellet combustion is presented in Table 4. It can be ascertained that the gases released during gasification match with fossil fuel.

4. Conclusion

Biomass has lower heating value than fossil fuel due to higher moisture content and high oxygen content. Experiments were carried out on preparation of solid fuel pellet from various biomass wastes such as coir pith and sawdust. The calorific values of the developed solid bio-fuel pellets have been estimated and compared with fossil fuel. It has been observed that the solid bio-fuel pellet prepared in the present investigation showed good calorific values. A maximum calorific value of 22,593KJ/kg has been obtained.

References

- Alejandro Amaya, Natalia Medero, Nestor Tancredi, Hugo Silva, Christina Deiana., Activated carbon briquettes from biomass materials, *Bioresource Technology*, 98 (2007).1635-1641
- Catharina Erlich, Emilia Bjo"rnbohm, David Bolado, Marian Giner, Torsten H. Fransson Pyrolysis and gasification of pellets from sugar cane bagasse and wood Fuel 85 (2006). 1535–1540
- Fabienna Rabier, Michael Temmerman, Thorsten bohm, Particle density determination of pellets and briquettes, *Biomass and Bioenergy* 30 (2006). 954-963.
- Maria Olsson, Jennica Kjallstrand, Goran Petersson, specific chimney emissions and biofuel characteristics of softwood pellets for residential heating in Sweden, *Biomass and Bioenergy* 24 (2003). 51-57.
- Ndiema.C.K.W, Mpendazoe.F.M and Williams.A, Emission of pollutants from a biomass stove, *Energy convers Mgmt* Vol. 39, No 12, (1998). 1357-1367.
- Olsson BA,Bengtsson J,Lundkvist H. Effects of different forest harvest intensities on the pools of exchangeable cations in coniferous forest soils. *Forest Ecology and Management*. (1996). 84:135–47.
- Palchonok G, Leckner B, Tullin C, Martinsson L, Borodulya, A. (2002). Combustion characteristics of wood pellets. Pellets 2002 international conference, Stockholm, Sweden, September 2–6, 2002. p. 105–9.

Table 1. Combination of raw material and additives and their mixing ratio

Sample/ Combinations	Raw material			Additive	Mixing ratio
	<i>Tectona grandis</i> saw	<i>Pterocarpus indicus</i> saw	coir pith	Neem gum	
Sample 1	√			√	1:3
Sample 2		√		√	1:3
Sample 3	√	√		√	1:1:3
Sample 4			√	√	1:3
Sample 5	√		√	√	1:3
Sample 6		√	√	√	1:1:3
Sample 7	√	√	√	√	1:1:1:3

Table 2. Moisture content of raw material before and after seasoning

Sl.No	Raw material	Moisture content (%)	
		Before seasoning	After seasoning
1	<i>Tectona grandis</i>	11	6
2	<i>Pterocarpus indicus</i>	12	7
3	Coir pith	20	11

Table 3. Characteristics of Solid pellet prepared at various combinations

Sample	Raw Material		Pellet			% increase	
	ρ_r gcc ⁻¹	CV (KJkg ⁻¹)	ρ_p gcc ⁻¹	CV (KJkg ⁻¹)	% ash content	ρ	CV
Sample I	0.22	13045	0.8	14697	1.5	72.5	11.2
Sample II	0.25	14500	0.87	16047	1.5	71.2	9.6
Sample III	0.27	14183	1.09	18046	1.2	75.3	21
Sample IV	0.23	15500	0.87	18061	4	73.56	14.18
Sample V	0.26	15887	0.84	18893	2.1	69	15.91
Sample VI	0.27	16167	0.97	19061	1.8	72.16	15.18
Sample VII	0.29	16500	1.3	22593	1.6	77.69	26.96

Table 4. Emission analysis of solid pellets during gasification

Sample/Gases		CO	CO ₂	NO ₂	SO ₂	VOC	Trace gases
Sample I	Raw	0.54	98	0.19	0.04	0.43	0.1
	pellet	0.53	52.2	0.1	0.004	0.21	0.06
Sample II	Raw	0.46	98.36	0.23	0.07	0.12	0.16
	pellet	0.23	53.88	0.13	0.009	0.09	0.11
Sample III	Raw	0.62	98.51	0.23	0.06	0.41	0.15
	pellet	0.41	42.96	0.09	0.004	0.2	0.08
Sample IV	Raw	1.27	97.5	0.29	0.12	0.59	0.2
	pellet	1.2	53	0.23	0.09	0.29	0.14
Sample VII	Raw	1.02	98	0.2	0.1	0.4	0.16
	pellet	0.4	39.79	0.14	0.06	0.2	0.1



Study on the Implementation of Green Supply Chain Management in Textile Enterprises

Fengfei Zhou

Tianjin Polytechnic University

Tianjin 300160, China

Tel: 86-22-2452-8438 E-mail: zhoulengfei@tjpu.edu.cn

Abstract

The green supply chain management is a sort of modern management mode which could comprehensively consider the environmental influence and resource utilization efficiency in the whole supply chain and how to implement the green supply chain management in special industrial operation at present has become into one of hotspot problems. This article mainly studied the core contents that textile and apparel enterprises implemented green supply chain management.

Keywords: Green supply chain, Textile and apparel enterprises, Implementation principles

1. Introduction

Textile and apparel products are traditional products to earn foreign exchange through export in China, and for a long term, China has been the biggest export trade country of textile and apparel in the world. But since entering into the 21st century, Chinese textile and apparel industry begun to face increasingly serious commercial environments, for example, the world textile and apparel trade cancelled the quota limit, and the international trade walls accumulated, and the formation of global information network and global market and the acceleration of technical reform make consumers' demands develop to the directions such as diversification, individuation, functionality and environmental protection with high requirements, and Chinese resources are increasingly deficient, and the environment is gradually depredated. Under this domestic and foreign commercial environment, the future survival and development of Chinese textile and apparel industry face large challenge. Simple management mode of "purchase to export" or the production and management mode of "vertical integration" have made the Chinese textile and apparel industry lack in activity, innovational ability and insufficient international competition. Under this background, the idea of "horizontal integration" begins to rise, and as the representative of this idea, the supply chain management increasingly prevails, and the green supply chain management has gradually become into the new concept for the sustainable development of the enterprises. However, it is not the simple problem of concept to really implement the green supply chain management in enterprises, and there are large numbers of works to do. This article mainly studies the core approaches and principles that textile enterprises implement the green supply chain management.

2. Core contents that textile enterprises implement green supply chain management

2.1 Establishing the strategic assets view of green textile supply chain

Since the concept of green supply chain management was first put forward by US Michigan State University in 1996 (Handfield, 1996, P.1295-1297), domestic and foreign academe begun to study various aspects of the green supply chain management (Beaman, 1999, P.332-342, Joseph, 2003, P.397-409, Jiah-Bing, 2005, P.287-313, Aref A, 2005, P.330-353, Samir K, 2007, P.53-80, Wu, 2003, P.86-88, Wu, 2004, P.1-3, Liu, 2006, P.27-30, Wang, 2003, P.11-16, 47). Some foreign famous multinational companies such as Ford Motor Company, Hewlett-packard Company, Valuable Clean Group and General Electric Company regarded the supply chain management as the strategic assets and corporate cultures acquiring corporate competitive advantage to filter into various parts, various departments and various employees. The supply chain has been utilized as the strategic weapon to rewrite the competitive law in the industry and impel competitors to have to develop themselves. But for Chinese textile and apparel enterprises, it is a challenge, and if Chinese textile and apparel enterprises want to change "made in China" to "created by China" and walk on the road of sustainable development, they should implement not only green production, but also the green supply chain "from cradle to recurrence", that is to say, the green supply chain should be regarded as the strategic asset of enterprises and

the strategic supply chain management should be implemented.

First, the green supply chain strategy composed by five basic collocation factors including green operation strategy, green outsourcing strategy, green channel strategy, green client service strategy and green asset network should be established. Second, the green supply strategic culture should be established, and the green supply chain management should be integrated into enterprise culture. Finally, the green supply chain strategy which can be organically integrated with green product strategy and green market strategy should be developed. Therefore, the green supply chain strategy which can accord with the competitive strategy, client demand strategy, strength status of textile and apparel enterprise and fit in with the environment should be developed.

2.2 Developing a flow system of green textile supply chain

When Chinese textile and apparel enterprises confirm the strategic status of green supply chain, they should describe a blueprint about green supply chain to integrate the rules of the flow relationships among various operation units in the supply chain, ensure the harmony among various flows with the base establishments of the supply chain and achieve the aim of the green textile supply chain. As viewed from the management objective, this blueprint should not only acquire the corporate competitive advantage and economic efficiency through implementing green supply chain management, but also reduce the negative influences of management to the least extent and maximize the social efficiencies such as the utilization rates of resource and energy. As viewed from management objects, the blueprint should include five aspects. The first one is the material suppliers which are middling enterprises such as fiber manufacturer, resin manufacturer, dye manufacturer and accessories manufacturer. The second one is the manufacturers which produce the middle products or final products such as yarn manufacturer, textile manufacturer, printing and dyeing manufacturer, apparel manufacturer and composite material manufacturer. The third one includes operators, distributors and shopkeepers. The fourth one includes consumption units or consumers. And the final one includes reclaim disposal manufacturers which compose an integrated positive supply chain and reverse supply chain with other suppliers, manufacturers, operators, distributors and consumers (Jiuh-Biing, 2005, P.287-313, Aref A, 2005, P.330-353). In the green textile supply chain management, the management objects become into the strategic partners among enterprises through many basic flows such as green plan, green stock, green manufacturing, green distribution, green logistics, green consumption and green reclaim. At the same time, to ensure the order of various flows and maximize the performance of the whole green supply chain, many technical support, information support and mechanism support such as decision-making support system, information management system, green evaluation system and support guarantee system should be established. According to former research results (Jiuh-Biing, 2005, P.287-313, Wu, 2003, P.86-88, Wang, 2003, P.82-87), combining with the characters of textile apparel industry, we develop the green textile supply chain flow system which is seen Figure 1.

2.3 Designing an organization of performance based on green textile supply chain

The operation flow needs corresponding organization structure. As viewed from the strategic status and flow system of the green supply chain management, the organization design of Chinese textile and apparel enterprises also need to add a green smartness integration supply chain organization (seen in Figure 2). The organization should possess following characters (Shoshanah, 2006). First, it can support the whole competitive strategy of the enterprise. Second, it has the skills and the core ability to implement all supply chain flow among the interior of the enterprise with its strategic partners. Third, it has established the effective green performance evaluation system. Fourth, it should follow a series of feasible design principle including the principle that form obeys the function (the supply chain organization must really reflect the green supply chain flow) and the equal principle of flow and responsibility and ability (each flow should arrange corresponding function department or responsible personnel takes on corresponding function and possesses corresponding ability). At the same time, the organization should possess following characteristics (Xu, 2004, P.80-82). The first one is the whole cooperation, and in the process of cooperation and interaction, the decision-making, execution, cooperation, feedback, follow and emergency disposal should be developed. The second one is the smart reaction, and aiming at complex and changeable market and competitive development, the organization should quickly make reasonable reactions and harmonize enterprise to implement new resource distribution and strategic and tactic adjustment. The third one is the three-dimensional communication, and in different enterprises, various levels operation and decision-making layers, the organization can implement three-dimensional information transfer and communication. The fourth one is the process drive, and the organization should drive the team through harmonizing the environment and process.

2.4 Establishing the strategic cooperation mode of green textile supply chain

The supply chain of textile apparel is longer than other supply chains in other industries, and for the whole supply chain, the latter includes many suppliers. But in fact, more enterprises are gradually reducing the strategic range, and they more and more focus on few core abilities. So the effective cooperation among enterprises in the green textile supply chain becomes into the base to acquire the best performance of the green textile supply chain management, and it is the most important strategic activity for enterprises, that is to say, to establish the cooperation relationship is same

important with technological innovation, and the enterprise which possess the ability of effective cooperation can acquire effective competitive advantage. However, few executive officers of green textile supply chain can give a clear and specific definition of cooperation, because the cooperation comes down to many aspects which include not only many cooperation types, but extensive mutual activities, and information sharing among operation units and the R&D of long-term production and marketing items.

At present, according to the cooperation extent and profundity, the cooperation partnership can be divided into four sorts such as trade type, cooperative type, harmony type and cooperation type. The cooperation partners of trade type devote their minds to enhance the simplicity of trade execution and few of them are absorbed in reducing the cost of supply chain management and enhancing the income of supply chain. This sort of cooperation relationship needs few advanced information system, and it is the most basic cooperation relationship at present. The cooperation of cooperative type possesses higher level of information sharing, and it generally implements information communication through special electric data exchange network and internet. The cooperation of harmony type possesses more complex basic establishment and flow of information sharing than the cooperation of cooperative type, and both cooperation relationships are closer and they more depend on their ability each other. This sort of cooperation relationship needs the negotiation and compromise with higher level, and they all expect to benefit from long-term cooperation, and this cooperation is fitter for the key supply chain partners with strategic meaning. The cooperation of cooperation type can mutually invest in R&D project and the development project of intellectual property rights, and the sharing degree covers from entity assets to knowledge assets even to the human resource. This sort of cooperation generally is called as "strategic alliance" which can not only share information but also develop information.

Though the strategic cooperation modes of the green textile supply chain are different, but the textile enterprise should establish "key" and "strategic" clients and suppliers accruing the rule that "20% of clients will bring 80% of profits for the enterprise". The concrete method is to establish a selectable evaluation standard to evaluate and select the cooperation relationships and cooperation partners according to many special demands such as green strategy, culture, organization and technology. At the same time, textile enterprises also should follow following instructive principles to ensure the success of cooperation relationship. First, simplify the interior cooperation before cooperation. Second, customize the cooperation mode according to the importance degrees of cooperation partners. Third, ensure to sharing knowledge and information and assume mutual risks and benefits among cooperation partners. Fourth, trust each other. Fifth, confirm every cooperation partner's anticipation. Sixth, utilize the technology to support the cooperation relationship.

2.5 Establishing a performance evaluation and management system of green textile supply chain

For the textile enterprise which first introduces the green supply chain management, the establishment of the green textile supply chain performance evaluation and management system is the effective tool, and the effective supply chain performance evaluation system can tell enterprise whether various parts in the positive supply chain and reverse supply chain are really exerting function, and help enterprise to diagnose problems and continually correct problems. First, we should add green indexes into the general supply chain evaluation index system to establish effective green textile supply chain evaluation index system which can exactly reflect the green health status of the textile enterprise supply chain. Second, we should utilize the green textile supply chain evaluation index to support the strategic aim for textile enterprises and implement effective green textile supply chain performance management. Effective supply chain performance evaluation system must include following three sustainable activities (Anne-Marie, 2006, p.1427-1432), (1) making quantitative aims to accord with plan and budget, (2) establishing individual objective and department objective to accord with the total objective of textile enterprise, (3) establishing clear follow evaluation process and the mechanism and program of management performance.

At present, there are many articles to study the supply chain performance evaluation index system, and the structure research of the performance measurement system mainly includes two tendencies, and the first one is to establish a new system based on the advice model, and the second one is to adopt the performance measurement system with multiple advices. The performance evaluation and management system of the textile supply chain should possess following characters (Anne-Marie, 2006, p.1427-1432). First, the system has been implemented in other industries, and it is not only the concept theory. Second, the system is designed based on the environment of the supply chain. Third, the management system should be composed by the performance measurement which can be easily operated. The supply chain operation reference model (SCOR) is the first supply chain reference model based on performance measurement, and it has been in the growth stage of lifecycle and become into the standard in the industry. It is the most popular supply chain reference model which is adopted and accepted in the world. Therefore, in the performance evaluation system of SCOR, we can add green indexes about textile enterprises to establish the green textile supply chain performance evaluation and management system.

3. Conclusions

It has important meaning to implement green textile supply chain management for the sustainable development of

Chinese textile enterprises and the whole industry, and it offers an ideal management mode for the harmony development of economic benefits and social benefits in Chinese textile enterprises. But at the same time, to really implement green supply chain management, there are works to do, we should not only establish the strategic assets view of green textile supply chain, but establish organization, cooperation mode and performance management system in the process of implementation.

References

- Anne-Marie & Jolly-Desodt. (2006). Benchmarking of the textile garment supply Chain using the SCOR model. *2006 international conference on service systems and service management*. Troyes of France. V3. P.1427-1432.
- Aref A. Hervani and Marilyn M. Helms. (2005). Performance measurement for green supply chain management. *Benchmarking: An International Journal*. No.12(4). P.330-353.
- Beaman, B. M. (1999). Designing the green supply chain. *Logistic Information Management*. No.12(4). P.332-342.
- Handfield R B. (1996). Green Supply Chain: Best Practices From the Furniture Industry. *Proceedings Annual Meeting of the Decision Science Institute*. USA. No.3. P.1295-1297.
- Jiuh-Biing, Sheu, Yi-Hwa, Chou & Chun-Chia Hu. (2005). An integrated logistics operational model for green-supply chain management. *Transportation*. Research Part E41. P.287-313.
- Joseph Sarkis. (2003). A strategic decision framework for green supply chain management. *Journal of Cleaner Production*. No.11(4). P.397-409.
- Liu, Qijun. (2006). Study on Supply Chain of Green Textile. *Journal of Zhejiang Provincial Party School*. No.6. P.27-30.
- Samir K. Srivastava. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews*. No.9(1). P.53-80.
- Shoshanah Cohen & Joseph Roussel, interpreted by Wangrong et al. (2006). *Strategic Supply Chain Management*. Beijing: People's Post and Telecommunication Publishing House.
- Wang, Nengmin, Yangtong & Qiao, Jianming. (2003). Study on Green Supply Chain Management. *Industrial Engineering Journal*. No.10(1). P.11-16, 47.
- Wang, Yingluo, Wang, Nengmin & Sun, Linyan. (2003). The Basic Principles of Green Supply Chain Management. *Engineering Science*. No.5(11). P.82-87.
- Wu, Dichong & Gu, Xinjian. (2003). Study of Green Textile Supply Chain and Its Organization. *Journal of Textile Research*. No.24(1). P.86-88.
- Wu, Dichong. (2004). Study on Supply Chain of Green Textile. *Silk Monthly*. No.12. P.1-3.
- Xu, Yimin. (2004). The Design of Order-oriented Agile Supply Chain Organization. *Logistics Sci-Tech*. No.8. P.80-82.
- Yang, Hongjuan & Tian, Cungang. (2004). The Sustainable Development Mode of Yunnan Enterprises: Green Supply Chain Management. *Inquiry into Economic Problems*. No.11. P.73-75.

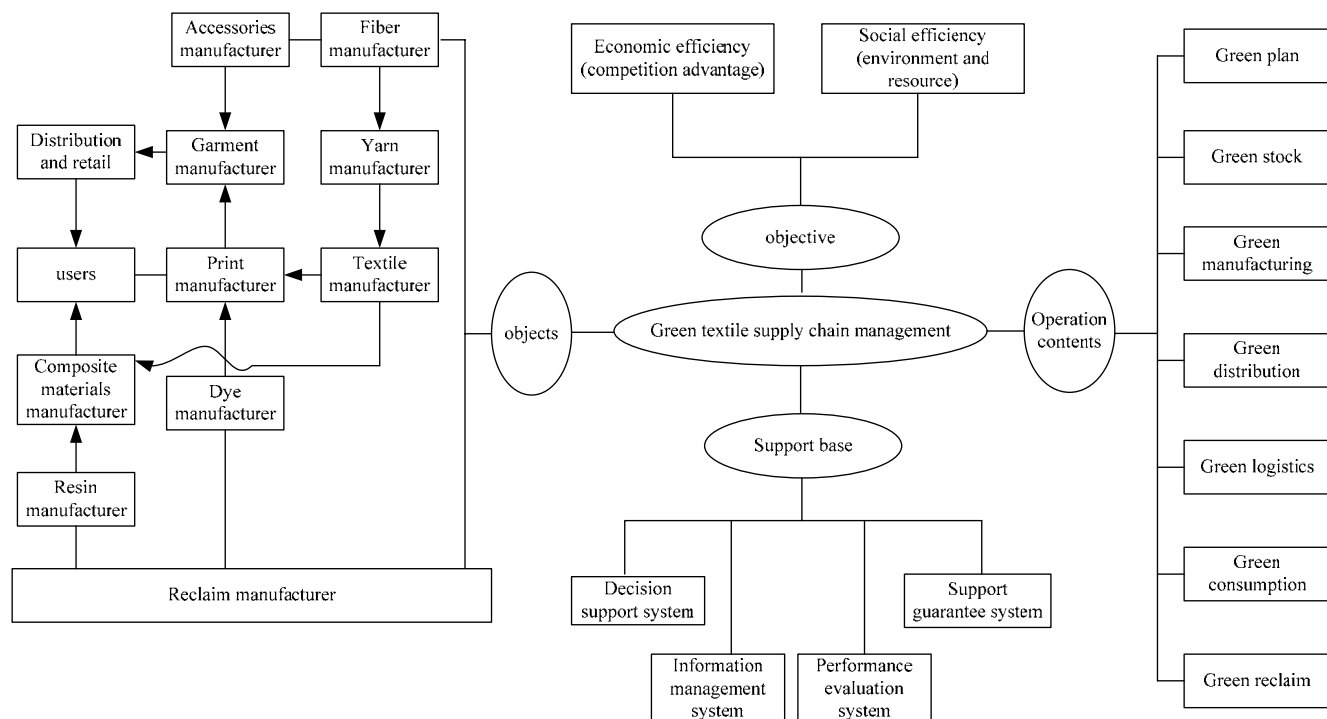


Figure 1. System of Green Textile Supply Chain Flow

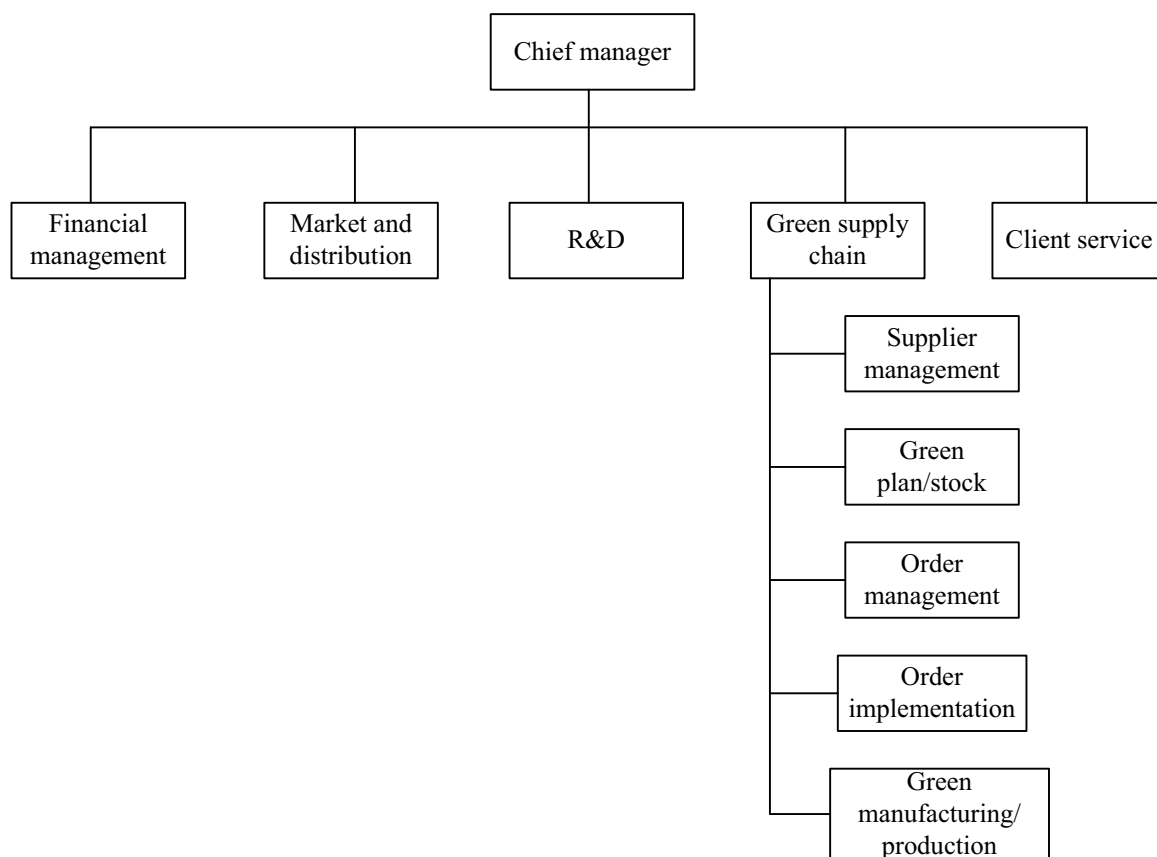


Figure 2. Organization of Green Smartness Integration Supply Chain



Malaysian Agricultural: Conventional and Extended Thoughts

Pek Chuen-Khee

Department of Economics

Universiti Tunku Abdul Rahman

Selangor D.E., Malaysia

Tel: 6-012-682-3811 E-mail: pekck@mail.utar.edu.my

Abstract

The survival of the agricultural industry from the 1997 financial crisis attack ticks off the importance of this once ‘sun-set’ industry and the re-emphasis of its role as a growth catalyst to Malaysia. Agriculture, unlike the past, is no longer solely a food-based contributor but plays important non-food roles, which are multifunctional; economic, social, cultural and food security. This multifunctionality role of agriculture warrants sustainable development in the longer run. The current scenario of the Malaysian agricultural, specifically sustainable oil palm planting is deliberated against the negative claims of the world environmentalist. Extended thoughts on the possible ways of sustaining economic development through the idea of ‘*back to where you belong*’, equity and the possible changes of comparative advantage when ecology is considered, and efficiency and equity of ecosystem conservation are discussed.

Keywords: Agricultural multifunctionality, Sustainable development, Conventional and Extended thoughts

1. Introduction

The Brundtland Commission (1987) defines sustainable development as growth that “meets the needs of the present generation without compromising the ability of future generations to meet their own needs”. As nations grow and standard of living rise, these needs become more complicated and expand into further dimensions. There has been growing consensus on the important linkage of environment and growth in the past years, especially in the context of sustainable agricultural as an aspect of economy growth and preservation of the ecological systems.

Why is agriculture unique to sustainable development, chiefly to the countries of ASEAN? The post-mortem of the 1997 financial crisis shows that agriculture is the only industry that could withstand the attack then. Agriculture continues to contribute to the growth of ASEAN not only in terms of Gross Domestic Product (GDP) but also job opportunities in terms of employment. The top three ASEAN countries whose GDP are highly dependent on agriculture is Lao PDR (more than 50 percent), Myanmar (45 percent) and Vietnam (24 percent). On the other note, this sector contributes towards 85 to 90 percent of the total employment in Lao PDR, 70 percent in Vietnam and 47 percent in Indonesia.

In Malaysia, these contributions by the agricultural sector are relatively lower. In terms of GDP, it contributes only approximately 8 percent and employment 16 percent. Malaysia has been more focused on the secondary and tertiary industries during the pre-financial crisis years but this ‘sun-set’ industry of agriculture has been re-emphasised of its role as a growth catalyst, resulting from the crisis post-mortem.

Sustainable development does not edged solely on environmental concerns but much more, which includes environmental sustainability, economic sustainability and socio-political sustainability. Environmental issues in agriculture basically relate to the dominance of agriculture with respect to natural resource use and its impact on the ecosystems. As discussed in the work of Jamal (2006), agricultural development requires the use of more land, water and chemical like fertilizers and others. Jamal found that a one percent change in the net export of palm oil leads to an increase of demand for land and agricultural chemicals by 0.25 and 0.3 percent respectively. In line with the aspiration of sustainable growth, the Malaysian government has only cleared old lands, but not virgin forest, to meet the demand for land in palm oil production. In addition, Azmi (2006) exerts that the country is aiming to lower the chemical inputs in tandem with the land management for palm oil use.

There are various legal and regulatory frameworks in Malaysia that governs the environmental and agricultural management to spur governance of sustainable growth like the National Agricultural Policy (NAP), Environmental Quality Act, National Environment Policy, National Conservation Strategy, National Forestry Policy, National Policy on Biodiversity and others. In the latest Third NAP, more focus has been given to the environmental aspect of agriculture employing two new strategic approaches, i.e. the agroforestry, and product-based approaches. The former approach aims at addressing the increasingly scarce resources like land while the latter approach is undertaken to reinforce and

complement the agro-industrial development by strengthening the inter and intra-sectoral linkages including the development and expansion of intermediate and supporting industries.

Under the NAP3 new policy thrusts, strategies and implementation are focused on national considerations like food security, productivity, inflation, enhancing exports and reducing unproductive imports and sustainable use of natural resources. However, in this new policy there are still rooms for more consideration of the agricultural multifunctionality (AMF) dimension as a strategic tool in ensuring sustainable growth. AMF is defined as non-traded services provided by agriculture, known also as non-trade concerns (NTCs) in World Trade Organization (WTO) rules.

The European Union (EU), Switzerland, Japan and South Korea are enthusiasts of AMF who seek flexibility in tackling issues related to environment, social and rural development, and food security through agriculture and land-use in an integrated manner. However, the group of food exporting countries i.e. the Cairns Group, which Malaysia and most of the ASEAN countries are members, throws much opposition and derision of the concept due to possible strengthening of protectionism under the guise of 'multifunctionality'.

This paper aims to discuss some of the conventional thoughts of sustainable environment and offer some extended thoughts on AMF. This hope can advocate further governmental discourse and intervention for a 'more AMF' agricultural management in the country.

2. New Dimension- Agricultural Multifunctionality

The conventional manner of defining agriculture has evolutionalised from only a single role of food supply to multiple roles to include non-food benefits, better termed as AMF. These extended roles include the functions of economic, social, environment, food security and cultural. They blend well with the concept of sustainable development with calls for not only the environmental concerns but also environmental sustainability, economic sustainability and socio-political sustainability as discussed earlier. The followings are the discussion on those functions as extracted from the work of Jamal et al. (2006):

2.1 Economic function

This role relates to the direct economic benefits accrued to farmers from crop planting activities. Jamal found that average farm projects in his sampling site have had slight positive effects on agricultural income and consequently, on total income generation in 2004 and 2005 relative to the previous years.

2.2 Social function

This function is discussed in three different contexts, i.e.:

2.2.1 Altruism value (AV)

This is the benefit derived from the traditional sharing of wealth made possible through paddy plantation especially in the muslim community. In the same work, Jamal estimated the AV to be USD10.3 million.

2.2.2 Employment opportunities

Even though agriculture contributes only 16 percent of the total employment in the country, paddy plantation specifically, does play its role in the provision of employment. On average each hired labourer received payment of some USD 7.90 per day and aggregate returns per annum or the value of employment opportunity benefits is highly substantial at USD 31 million.

2.2.3 Sheltering function (SF)

This function is critically important in times of economic recession as a taker of excess or unemployed workforce from urban areas. In Malaysia, agriculture has successfully played this role during the 1997 financial crisis. The SF aggregate value during the entire crisis period from 1997–2000 stands at USD 126 million.

2.3 Environmental function

Alike the social function, this function is discussed in three different contexts, i.e.:

2.3.1 Flood mitigation function

Paddy fields are good rain water storage 'tanks' during the monsoon seasons, preventing floods in the nearby cities. Jamal asserted that this intangible value is one the most valuable contribution of paddy fields to the ecosystem. The estimated value of the flood mitigation function is approximately USD 0.034 million.

2.3.2 Heat mitigation function

Literatures show that paddy fields play an important role in heat mitigation. Empirical investigation found that USD 53,350 can be saved from the cost of cooling systems by the reliance of heat mitigation on the ecological function of paddy fields.

2.3.3 Air pollution reduction function

Air pollution is one of the environmental problems in the country, much so with the presence of haze sent by the forest fires in the neighboring country, Indonesia during the dry seasons. Haze contains high density of dust particulate matter, PM_{10} . During the hazy days, the PM_{10} concentration can reach up to $60 \mu\text{g}/\text{m}^3$, 20 percent higher than the standard level. Theoretically, air pollution in an area can be reduced with the presence of paddy fields, as the dust particles can be absorbed by the water retained in the fields. On average the state of Kedah, which is renowned for her paddy fields has lower Air Pollutant Index (API) reading than the more industrialized state of Selangor. Study has found that a total welfare improvement value of USD 2.03 million is accrued to the residents of Alor Setar, the capital city of Kedah state, due to the lower air quality resulted from the ecological functions of paddy fields.

2.4 Food security

This function of the AMF is to ensure adequate level of rice production in the country at all times for the ever increasing population. Report has found that with a simulation of 20 percent decline in rice production due to the liberalization of free trade, urban Malaysians are willing to pay (WTP) a price premium of 33 percent i.e. around USD 1 per month. As an aggregate the estimated value of this function is USD 9.2 million annually.

2.5 Cultural function

This cultural function is an addition to Jamal's selected functions. Like Japan and many other countries, Malaysia values agricultural activities and rural landscape dearly not only for commercial reasons like food exports and tourism but the cultural values they offer that help create strong communal bonds. Agricultural is a way of life to the Japanese as evident in the work of Goda, Kada and Yabe (2006) which talks about these amenities as the pride and 'brand name' of their hometowns. Autumn festivals as thanksgiving of good harvest and 'Obon' reunion time are still being practiced widely in Japan where family members return to their hometowns in the rural areas to worship their ancestors. In Malaysia, the Gawai Day celebrated in June annually by the Dayaks (natives of Sarawak state) is held for the similar reason of thanksgiving to God for good harvest. Every year crowds of tourists enjoyed themselves in this celebration which is uniquely 'agricultural-oriented'.

Acknowledging the increasing importance of these agriculture multifunctions, there are efforts in promoting these new dimensions in the country. Activities aim at inculcating more awareness and appreciation of the public are based on the objectives of making more multimedia awareness of AMF and a good example is the television advertisement of Sime Darby (the biggest oil palm producing company in the world), showing the importance of having sustainable palm oil production towards a more balanced growth.

These are important initiatives but may not be sufficient to drive more intervention from the government sector into recognizing AMF as a crucial element in sustainable development. The following sections discusses call for sustainable development (particularly in palm oil production) due to conventional reasons and offer some extended profound thoughts on AMF which may be worth deliberating.

3. Issues towards sustainable development

Currently in the country, the production of palm oil is faced with more sustainable issues than the plantation of other crops. There seems to be some mismatch of perception on the concern of sustainable growth in terms of land management used for oil palm plantation between the Malaysian government and international non-governmental bodies (NGOs). These NGOs and the Western countries are condemning Malaysia on the way forests are cut to make way for palm oil plantation especially in the Sabah state.

3.1 The negative claims

Statistics show that the land area in Sabah used for palm oil plantation has increased nearly 2.5 folds in 2004 (1,200,000 hectares) as compared to 1994 (500,000 ha) as quoted in Rahimatsah (2007). The NGOs perceives that the extension is through cutting of virgin forests. Jeffrey Sachs once claimed that Sabah is the most unique place on earth in terms of environmental and ecological endowments and he would like his future generations to have the equal opportunity to enjoy these gifts of nature. Therefore if more and more land is cleared via deforestation for palm oil production, the Sachs juniors may not been able to enjoy the bequest values of the ecosystems of Sabah that are very much appreciated by Sachs senior.

The conventional debates of sustainable development in palm oil production are not directly related or caused by the technological frontier but more of the concerns on the origin of the four million ha (2007) of land used as oil palm estates in the country. The idea of clearing forests for the sake of 'agri-commercial' reasons will affect the natural habitats of priceless animals and flora and fauna. The tigers, Sumatran rhinoceros, Asian elephants and orangutans are some of the very unique animals that are affected by land conversions for commercial uses. The Orangutans, especially, are faced with serious habitats problems and high possibility of extinction thanks to the estate expansion to reap high returns of palm oil in the world market.

The other critical concern is the destruction of peatlands, which is crucial 'carbon sink' and 'water retention' role player. Land clearing for agricultural use will see peatlands tidied commonly through the traditional method of burning which releases huge concentration of carbon dioxide into the air due to the 'carbon sink' role of the peatlands. Evidently, during the 1997 Indonesia forest fires which see many peatlands destroyed and responsible for the vast increase of world carbon dioxide levels, an estimated 0.81 to 2.57 Gt of carbon was released and that was equivalent to 13-40 percent of the amount released by fossil fuel burning globally.

3.2 *The real scenario*

Commercial profits aside, the Malaysian government is dismissing all these baseless allegations as the country values highly and is a staunch devotee of sustainable development. The land areas used for palm oil production are from old logging areas or unproductive forests rather than the virgin rainforests as claimed. Tan et al. (2007) asserted that 64 percent of total land mass in Malaysia is rainforests as compared to United Kingdoms (UK) with a mere 12 percent. In addition to that, oil palm plantations only occupied 10 percent of the total mass land in the country. Besides, the government aims to plant 500,000 ha of forest plantation, double the existing ones in the states of Johor, Pahang, Sabah and Sarawak. So, if Malaysia is to be charged guilty in 'raping' the virgin rainforest, what about UK?

In the same work of Tan et al., it was reported that from 1990 to 2005, there was only less than one million ha of new land being converted into palm oil estate, but not as massively claimed by the west. In this study, it was also suggested that oil palm plantations are more effective than rainforests in playing the role of 'carbon sink' in terms of assimilation of dry matter per ha per year. Several studies indicated that biodiversity of flora and fauna in oil palm estates are not only stably unaffected but has attracted many species of birds, butterflies and mammals, notably even rare species like leopard cats.

A caucus "Roundtable on Sustainable Palm Oil" (RSPO) to promote the growth and use of sustainable palm oil and forging stronger co-operation within the supply chain and other stakeholders was established in 2004. Malaysia as one of the founding members is actively participating in managing RSPO activities and committing herself to the RSPO Principles and Criteria (e.g. transparency of management, commitment to long-term economic and financial viability, responsible in conservation of natural resources and biodiversity and others) to ensure sustainable palm oil production. Sustainability in palm oil is analogous to sustainability in the Malaysian agriculture due to its position as the number one agricultural crop in the country.

Complementing the RSPO is the Best management practice (BMP) that has been implemented and practiced in the country as initiatives towards agricultural sustainability. Operations from harvesting to production of oil palm products have been carried out consistently with the best approaches. Integrated pest management, use of organic fertilizers (from palm oil's empty fruit bunches), zero open burning and planting of leguminous crops (to minimize soil erosion) are some of the BMP.

4. Extended thoughts- the unconventional philosophy

The conventional concern of orangutans extinction in Malaysia may be relatively trivial if compared to the broader picture of long term optimality of resource use with limited agricultural land in the country. It is argued that the extinction of animals or plants species is still within the human tolerance level as many of such species like dinosaurs have been extinct from the world with not much externality been sacrificed or endured by mankind. But humans will be more greatly affected if one's country specifically, or the world generally, cannot sustain the supply of resources due to lack of suitable or productive crop land, and damaged ecosystems. It is an issue of vulnerability of the entire Malaysian economy and society.

While governmental and NGOs efforts and initiatives are mounted to address this problem, some extended thoughts are offered in this paper to re-look at agricultural sustainability beyond the conventional manner and consistent with AMF. The concept of extended comparative advantage and efficiency vs equity will be discussed in the following sections with the aim of addressing the vulnerability issue.

4.1 *Back to where 'you' belong*

The idea of planting crops only in their country of origin may be worth pondering. Famous street trees in Pretoria and Johannesburg named the 'jacarandas' are under threat as they are either to be felled or prevented from regenerating. Why bother about street trees? It has been claimed by some ecologists that jacarandas are invasive and would harm the biodiversity of the surroundings they inhabit. These trees are not domestically-originated, akin 'white-immigrant' from tropical and subtropical regions of South and Central America, Mexico, and the Caribbean, and hence they will draw more ecological resources to grow than the other native tree species. The continuation of planting jacarandas will lead to environmental resource inefficiency which is deteriorating to other local tree genus.

4.2 *Extended comparative advantage*

The ecological inefficiency caused by the jacarandas may shed some lights in broadening our thought in reassessing the concept of comparative advantage by David Ricardo. The principle of comparative advantage rests on the opportunity

cost of production rather than the absolute cost. The opportunity cost of production of a good can be measured in terms of the production unit of another good need to be reduced to increase production by one more unit.

The principle of comparative advantage shows that even if a country has no absolute advantage in any product (i.e. cost of productions are higher in all goods as compared to the other country), the country can still specialized and export the product for which she has the lower opportunity cost of production. However, in comparative advantage, only financial costs are considered. The non-financial costs, more known as non-market values, are left out.

With the call for sustainable development and advancement of non-market valuation methodologies, it is timely that the environmental impacts of specializing and producing a good or service be reflected in the total cost of production. The valuation of these non-financial values of ecosystems can be estimated using valuation techniques like the contingent valuation and choice model. The incorporation of these environmental values change the total cost of production and possibly alters the specialization of goods that a country should produce. A simple simulation is discussed to demonstrate this likelihood.

Assuming two countries, country M and N, share similar climate characteristics and are able to grow both crops, i.e. palm oil and paddy. Country M has more mountains and hilly lands than country N. The costs of producing one tonne of palm oil and paddy are USD 450 and USD 800 respectively in country M. In country N, they cost USD 600 and USD 1000 per tonne correspondingly. If absolute cost is considered, country M is more cost effective than country N in the production of both crops. However, comparative advantage shows that country M pays equal cost to produce 0.56 tonne of paddy as for one tonne of palm oil, while in country N, production cost of one tonne of palm oil is equivalent to 0.60 tonnes of paddy. The opportunity cost criterion says that country M should specialize and export palm oil while N should go for paddy. This specialization is based on the conventional comparative advantage which takes into account solely the financial costs.

The extended comparative advantage which considers the non-market values in the process of identifying which country specializes in which crop production may give a different outcome. In country M since there are more hilly lands than country N, clearing those lands for palm oil planting creates soil erosion which is costly to the environment. Unlike palm oil, planting paddy on hilly lands is not only safe but enhances the ecosystems. However, forest cutting is inevitable for cultivation of both crops. The environmental impact in planting palm oil is higher than paddy in country M. Assuming the reverse is true in country N as palm oil estates are more environmental friendly than paddy fields in terms of the carbon sink role they play.

Thus, these extra non-financial costs are to be calculated into the total production of those crops. Assuming non-market valuation techniques derived the environmental costs per tonne to be USD 550 for palm oil and USD 150 for paddy in country M and USD 200 and USD 650 for the same corresponding crops in country N. Table 1 and 2 show the possible changes in total cost of production, the opportunity costs of production and specialization when non-financial costs are reflected.

This simple example illustrates the possible change in specialization by both countries which share similar climatic background. This may offer a pointer for economists and countries to call for a worthy re-evaluation of crop production specialization to minimize long-term environmental impacts of crops from foreign land planted in local soils. This standpoint may be possibly valid as an extension from the prior discussion, i.e. *“That palm oil should after all not suitable to be planted in Malaysia but shall leave it to the countries of West Africa like Nigeria to grow as a native land of palm oil.”*

If the call to stop jacarandas from regenerating in Pretoria makes sense to us because it is invasive and environmentally unfriendly, then the notion of *“Back to where ‘you’ belong”* seems right. Malaysia should allow Nigeria to plant palm oil while concentrate on paddy production with equivalent commercial lost being compensated from the potential “palm oil market”, which is similar to the carbon market created to trade carbon emissions and compensate disadvantaged countries. On the other hand if Malaysia chooses to continue with her production of palm oil then some form of compensation should be paid to the ‘market’ for damage on ecological systems of the country accrued to palm oil plantation. This will make sustainable development in the context of AMF more realistic and feasible.

4.3 Efficiency and Equity

The issue of sustainable development is a question of efficiency in ecological management. Malaysia as a resource rich nation is always the focal point of discussion when comes to natural resources sustainability. World bodies are exerting pressure on the country to preserve and conserve as many rainforests as possible but they never talk about who should be paying for all these resource maintenance costs. For a developing country like Malaysia to maintain her forest areas bearing in mind that 65 percent of land are covered by rich and dense tropical forests is a mouthful and enduring mission.

There are several world renowned national parks in the country like the National Park, more known as Taman Negara, Bako National Park, Gunung Mulu National Park and others that require huge conservation funds from the state governments. Taman Negara, the world oldest tropical rainforest is mostly located in the relatively poorer state of Pahang,

whom pays for the conservation of the park. On one hand the state needs to be efficient in natural resources management but on the other hand the issue of social equity has to be addressed. Who shall pay these costs? It looks like the West and environmental NGOs value these parks more than the locals and as such these parks are open to probable development for commercial reasons in the future when funds are inadequate and growth for the quest of money dominates the passion for environmental services. It will not be surprising that a day will come where Taman Negara is developed by the Pahang state government for economic growth related motives.

At this juncture, the paper aims to highlight the need for a biodiversity market to create a world trust fund that would aid the high conservation costs of national parks in the country. The fund can channel monetary aids to the state government to ensure long-term sustainability of those parks which are dearly valued by the world. Chichilnisky, who proposed and wrote the global trading of carbon emissions with preferential treatment for poor countries which became part of the Kyoto Protocol adopted by 166 nations in December 1997, noted in her environmental sustainability conference lecture at Monash University Malaysia in December 2007 that she is working on a similar model for biodiversity market. With this market in place in the near future it will be excellent to see preferential treatment being given to the developing countries like Malaysia to preserve the ecological assets for long term sustainable growth in tandem with AMF. With the issue of equity probably resolved with the creation of the biodiversity market, efficiency in the world environmental management is made more feasible.

5. Conclusion

This paper aims to offer some unconventional philosophy of looking at the issue of sustainable development in the light of AMF on top of the traditional views.

Acknowledging the importance of AMF, this study calls for more intervention from the government and NGOs to ensure sustainable growth. The scope of addressing this issue is broadened into three extended thoughts of “Back to where ‘you’ belong”, extended comparative advantage and the struggle between environmental efficiency versus equity.

These thoughts shed some lights on the possibility of re-addressing the specialization of goods produced in a country when non-financial costs are considered. This may help to reduce and minimize energy extraction from nature used to grow crops which are more environmental-friendly when grown in native lands than foreign soils.

The issue of efficiency and equity has to be resolved in order to ensure the sustainability of ecosystems and biodiversity. The call for the setting up of a biodiversity market is timely to conserve the natural assets located in the land of poor or developing countries.

In short, new thoughts on addressing the issue of sustainable growth are essential and worth for deliberation. Though this paper offers limited insights regarding the notions of extended comparative advantage and efficiency and equity, nevertheless it drives some motivation for future researches.

Special acknowledgement

The author would like to accord credits to Professor Dr Jamal Othman of National University of Malaysia for his brilliant idea sharing of extended thoughts of sustainable development, and Professor Ryohei Kada of Yokohama National University, for his sharing of agricultural multifunctionality during his visit to Malaysia in February 2008.

References

- Azmi, M. A. (2006). Overview of agriculture in ASEAN member countries. Final report Country case studies on multifunctionality of agriculture in ASEAN countries, The ASEAN Secretariat and MAFF Japan. Jakarta, 2006.
- Goda, M., Kada, R. & Yabe, M. (2006). Concept and significance of multifunctionality of agriculture: A global perspective. Final report Country case studies on multifunctionality of agriculture in ASEAN countries, The ASEAN Secretariat and MAFF Japan. Jakarta, 2006.
- Jamal, O. (2006). New dimension for Malaysian agriculture amidst industrialization. Seminar proceedings of Multifunctionality and Revitalization of Agriculture. Editor: Ai Dariah et al. Indonesian Ministry of Agriculture, MAFF Japan and ASEAN Secretariat. Jakarta, 2006.
- Jamal, O., Nousa, N. & Arifin, T. (2006). Rural viability and environmental functions in Malaysian agriculture. Final report Country case studies on multifunctionality of agriculture in ASEAN countries, The ASEAN Secretariat and MAFF Japan. Jakarta, 2006.
- Rahimatsah, A. (2007). Oil palm and conservation in Malaysia: Experiences from Sabah. Second symposium on sustainable resource development in Brussels, 28 March 2007.
- Tan, K. T., Lee, K. T., Mohamed, A. R. & Bhatia, S. (2007). Palm oil: Addressing issues and towards sustainable development. *Renew Sustainable Energy Reviews*. Doi:10.1016/j.rser.2007.10.001 (Article in press).

Table 1. Total cost of production (financial costs only) and specialization

Country	Palm oil USD/tonne	Paddy USD/tonne	Opportunity cost & specialization
M	450	800	1 : 0.56 / Palm oil
N	600	1000	1 : 0.60 / Paddy

Table 2. Total cost of production (financial & non-financial costs) & specialization

Country	Palm oil USD/tonne	Paddy USD/tonne	Opportunity cost & specialization
M	1000 (450+550)	950 (800+150)	1 : 1.05 / Paddy
N	800 (600+200)	1650 (1000+650)	1 : 0.48 / Palm oil



The 0-1 Programming Solution for the Problem of Resource Allocation

Guoliang Luo & Xingang Zhao

School of Business and Administration

North China Electric Power University

Beijing 102206, China

Tel: 86-10-8079-8529 E-mail: LGL1965@126.com

E-mail: rainman319@ncepu.edu.cn

The research is financed by National Nature Fund of China (No. 70671042). (Sponsoring information)

Abstract

In this article, we first translated the problem of disperse resource allocation into the 0-1 programming problem, and put forward the special solution based on the relative difference quotient aiming at the particularity of resource allocation 0-1 programming model. And the example proved that the new algorithm was effective and fast.

Keywords: Resource allocation, 0-1 programming, Relative difference quotient, Feasible increasing direction

1. Introduction of the problem

In actual problems, we always need to allocate a sort of or many sorts of resources with certain quantity to many departments or units, and make the benefit achieve optimization. The mathematical model of this sort of problem is not complex for one sort of resource, and if suppose the gross of resource is a which should be allocated to n departments, the allocation quantum of the i 'th department is x_i , and the corresponding benefit function is $g_i(x_i)$, so the model can be denoted as

$$\max z = \sum_{i=1}^n g_i(x_i)$$

$$s.t. \quad \sum_{i=1}^n x_i \leq a$$

$$x_i \geq 0, i = 1, 2, \dots, n$$

In fact, because of differences of original base, geographic position, market orientation and using attention for various departments, even if we offer resources with same quantity to various departments, the benefits of various departments are not same, i.e. the benefit functions of various departments are different, and their function relationships are not certainly resolutions, and these characters of non-resolution and dispersion of benefit function make the resolution computation become more difficult. General operational research teaching materials all adopt the method of dynamic programming to solve the problem, and comparing with general method of exhaustion, the computation process could be simplified, but the time process is long and the computation quantity is large, especially for one of n , a is big at least. On the other hand, once the data of benefit sheet change, the former and the latter allocation projects are different, which couldn't be adjusted in time. Aiming at these problems, how to design more simple and effective algorithm?

2. 0-1 programming model for the problem of resource allocation

To the problem of resource allocation, we can establish possible allocation project in advance, and according to relative investigation and statistics, the benefit value c_{ij} brought when resources are allocated to the j 'th department d_j , and they are seen in Table 1.

Introduce 0-1 variables,

When $x_{ij}=1$, allocate resources to the j 'th department according to the i 'th mode.

When $x_{ij}=0$, don't allocate resources to the j 'th department according to the i 'th mode.

Because every department only can be allocated according to one sort of project, so we can establish the following mathematical model of 0-1 programming.

$$\begin{aligned} \max z &= \sum_{j=1}^n \sum_{i=0}^m c_{ij} x_{ij} \\ \text{s.t.} &\begin{cases} \sum_{i=0}^m x_{ij} = 1, & j = 1, 2, \dots, n \\ \sum_{j=1}^n \sum_{i=0}^m d_i x_{ij} \leq a \\ x_{ij} = 0 \text{ or } 1, & j = 1, 2, \dots, n, i = 0, 1, 2, \dots, m \end{cases} \end{aligned}$$

It is familiar 0-1 programming model. When the resource quantity is not large, and the allocation projects and the departments participating in allocation are few, we can apply the programming solution function in Excel software to solve the problem fast and conveniently.

3. Special solution for the resource allocation 0-1 programming model

When the resource quantity is large, and the allocation projects and the departments participating in allocation are more, the programming solution function in Excel software is inefficient to solve the problem. To the 0-1 programming problem, we usually use the filtration concealed enumeration method to solve it, and the method is to find a feasible solution first, and then obtain a filtration condition by using it, and don't test the feasibility for the point which doesn't fulfill the filtration condition. Though the operation quantity of the filtration concealed enumeration method is less than the enumeration method, but in actual application, it has two deficiencies.

(1) This method should first seek one feasible solution, but it doesn't give the method to seek the first feasible solution. When the limitation equations are more, and we could not distinguish which variable combination is feasible solution, we must solve the problem by the tentative method. This sort of method is blind, and sometimes we must try several variable combinations to find the first feasible solution.

(2) When the objective function value of the first feasible solution is different with the optimal value, the filtration condition confirmed by the objective function value is bad, and even if we continually improve the filtration conditions in the computation process, the computation quantity is still large.

In Huang, Huiqing's article (Huang, 2002, p.1052-1053), the author put forward a sort of new method to solve 0-1 integer programming. The new method first seeks corresponding objective function value Z to various variable combinations $(x_1, x_2, \dots, x_n)^T$, then sorts all objective function values by size, and tests the feasibilities of various solutions and confirms the optimal solution. If the optimal solution exists in the 0-1 programming, we will find the optimal solution through 2^n times at best. For the 0-1 programming model of resource allocation, because there are $m \times n$ 0-1 variables and the possible combination mode quantity of various variables is 2^{mn} , so the method still has too large computation quantity. For the large scale problem, it is not feasible.

For the 0-1 programming model of resource allocation

$$\begin{aligned} \max z &= \sum_{j=1}^n \sum_{i=0}^m c_{ij} x_{ij} \\ \text{s.t.} &\begin{cases} \sum_{i=1}^m x_{0j} = 1, & j = 1, 2, \dots, n \\ \sum_{j=1}^n \sum_{i=0}^m d_i x_{ij} \leq a \\ x_{ij} = 0 \text{ or } 1, & j = 1, 2, \dots, n, i = 0, 1, 2, \dots, m \end{cases} \end{aligned}$$

, if we don't consider the 0-1 limitation of the problem, we add the slack variable into the inequality limitation, and the coefficient matrix of its limitation condition is

$$A = \begin{pmatrix} 1 & 1 & \cdots & 1 & & & & & 0 \\ & & & & 1 & 1 & \cdots & 1 & & 0 \\ & & & & & & \cdots & & & \cdots \\ & & & & & & & 1 & 1 & \cdots & 1 & 0 \\ d_1 & d_2 & \cdots & d_m & d_1 & d_2 & \cdots & d_m & \cdots & d_1 & d_2 & \cdots & d_m & 1 \end{pmatrix}$$

, and the item of constant is $(1 \ 1 \ \cdots \ 1 \ a)^T$.

The problem must have the optimal solution, and to any $j \in \{1, 2, \dots, n\}$, the factor with $\{x_{ij} \mid i = 0, 1, 2, \dots, m\}$ in the base variable of feasible base exists and its quantity is only one. Aiming at this special problem, we put forward following special solution.

(1) Confirmation of initial project (feasible solution)

For the confirmation of initial project (feasible solution), we adopt the maximum proportion principle, i.e. the position which the relative efficiency of asset is maximum is first selected. The concrete computation block diagram is seen in Figure 1.

(2) Optimal adjustment

In this article, the allocation project of resource we consider is in the situation with equal step length, and suppose that any one department obtains more resources, it will produce more benefits. The 0-1 programming model of the problem is

$$\begin{aligned} \max z &= \sum_{j=1}^n \sum_{i=1}^K c_{ij} x_{ij} \\ \text{s.t.} &\begin{cases} \sum_{i=1}^K x_{ij} = 1, & j = 1, 2, \dots, n \\ \sum_{j=1}^n \sum_{i=1}^K d_i x_{ij} = a \\ x_{ij} = 0 \text{ or } 1, & j = 1, 2, \dots, n, i = 1, 2, \dots, K \end{cases} \end{aligned}$$

, denote the feasible field of the problem is Ω .

To conveniently describe the problem, we first introduce several concepts.

Definition 1. Denote $\xi(i, j, k) = \frac{c_{i(j+k)} - c_{ij}}{k}$ is the k 'th step relative difference quotient of the variable x_{ij} . When $k > 0$, it is called as the forward k 'th step relative difference quotient, and when $k < 0$, it is called as the backward $|k|$ step relative difference quotient.

Suppose

$$\begin{aligned} x &= (x_{10}, x_{11}, \dots, x_{1m}, x_{20}, x_{21}, \dots, x_{2m}, \dots, x_{n0}, x_{n1}, \dots, x_{nm})^T \in \Omega \\ y &= (y_{10}, y_{11}, \dots, y_{1m}, y_{20}, y_{21}, \dots, y_{2m}, \dots, y_{n0}, y_{n1}, \dots, y_{nm})^T \in \Omega \\ \text{where, } x_{k,i} &= \begin{cases} 1, & k_i = i_k^* \\ 0, & k_i \neq i_k^* \end{cases}, x_{k,i,j} = \begin{cases} 1, & k_i = i_k^* \\ 0, & k_i \neq i_k^* \end{cases}, y_{k,i} = \begin{cases} 1, & k_i = j_k^* \\ 0, & k_i \neq j_k^* \end{cases} \\ \text{so } \sum_{k=1}^n i_k^* h &= a, \sum_{k=1}^n j_k^* h = a, \text{ and } \sum_{k=1}^n (i_k^* - j_k^*) = 0. \end{aligned}$$

Definition 2. For the integer vector $m = (m_1, m_2, \dots, m_n)^T$, if $\sum_{j=1}^n m_j = 0$, so the integer vector is feasible.

Definition 3. For $x = (x_{10}, x_{11}, \dots, x_{1m}, x_{20}, x_{21}, \dots, x_{2m}, \dots, x_{n0}, x_{n1}, \dots, x_{nm})^T \in \Omega$ and the integer vector $m = (m_1, m_2, \dots, m_n)^T$, where $x_{k,i} = \begin{cases} 1, & k_i = i_k^* \\ 0, & k_i \neq i_k^* \end{cases}$, if $\sum_{k=1}^n \xi(k, i_k^*, m_k) \cdot m_k > 0$, so m is the increasing direction of x .

So it is obvious that the theorem.

Theorem. For the feasible solution of the resource allocation 0-1 programming model

$$x = (x_{10}, x_{11}, \dots, x_{1m}, x_{20}, x_{21}, \dots, x_{2m}, \dots, x_{n0}, x_{n1}, \dots, x_{nm})^T \in \Omega,$$

if the feasible increasing direction of x doesn't exist, so x is the optimal solution of the problem.

(3) Computation block diagram of special solution of 0-1 programming model for the problem of resource allocation
The computation block diagram is seen in Figure 2.

4. Concrete example

Suppose the benefit values of different resource allocation quantities in different departments are seen in Table 2, and the total quantity of resource is 14.

From the confirmation method of the initial project, we can obtain the initial project.

$$x_{21} = 1, x_{32} = 1, x_{53} = 1, x_{24} = 1, x_{25} = 1, x_{46} = 1, x_{37} = 1$$

The relative difference quotients of various step lengths of the feasible solution are seen in Table 3.

The feasible increasing direction is $(0, 0, 0, 2, 0, -2, 0)$, so the new feasible solution is

$$x_{21} = 1, x_{32} = 1, x_{53} = 1, x_{44} = 1, x_{25} = 1, x_{26} = 1, x_{37} = 1$$

, and the relative difference quotients of various step lengths of this feasible solution are seen in Table 4.

And the feasible increasing direction is $(0, 0, 0, 2, 0, -1, 0)$, so the new feasible solution is

$$x_{21} = 1, x_{32} = 1, x_{53} = 1, x_{44} = 1, x_{25} = 1, x_{16} = 1, x_{47} = 1$$

, and the relative difference quotients of various step lengths of this feasible solution are seen in Table 5.

Because the increasing direction doesn't exist in this feasible solution, so the optimal solution is

$$x_{21} = 1, x_{32} = 1, x_{53} = 1, x_{44} = 1, x_{25} = 1, x_{16} = 1, x_{47} = 1, \max z = 88.$$

5. Conclusions

In this article, we translate the problem of disperse resource allocation into the 0-1 programming problem. Aiming at the particularity of the 0-1 programming model of resource allocation, we put forward the special solution, i.e. first confirm the initial project by the principle first selecting the position which relative efficiency of asset is maximum, judge where more excellent feasible project exist by the forward relative difference quotient and the backward relative difference quotient. We also give the computation block diagram to confirm the initial feasible solution and the whole computation process, and the example and numerical experiment indicate the algorithm is fast and effective.

References

- Editing Team of Operational Research Teaching Material. (2005). *Operational Research (3rd Edition)*. Beijing: Tsinghua University Press. p.213-216.
- Huang, Huiqing. (2002). A New Algorithm for Zero-One Type Integer Programming. *Mathematics in Practice and Theory*. No.32(6). p.1052-1053.
- Huang, Zhenglong. (2007). Conversion of Optimized Models of Resources Allocation and Its Algorithms. *Journal of Central South University of Forestry & Technology*. No.27(2). p.122-125.

Table 1. Benefit values produced by different resource allocation quantities in different departments

Quantity of resource	Benefit values produced in various departments			
	1	2	...	n
0	c_{01}	c_{02}	...	c_{0n}
1	c_{11}	c_{12}	...	c_{1n}
\vdots	\vdots	\vdots	\ddots	\vdots
m	c_{m1}	c_{m2}	...	c_{mn}

Table 2. Benefit values produced by different resource allocation quantities in different departments (example)

Quantity of resource	No. of department						
	1	2	3	4	5	6	7
	Available profits						
0	0	0	0	0	0	0	0
1	9	1	1	9	6	4	6
2	11	10	4	15	9	8	15
3	13	14	12	23	10	12	20
4	13	17	21	23	11	16	24
5	13	20	23	24	12	25	25
6	19	23	24	32	16	25	31
7	20	26	32	36	24	27	38
8	28	31	34	44	28	27	41
9	29	32	40	51	36	33	41

Table 3. Relative difference quotients of different steps for the initial project feasible solution

step length	forward relative difference quotient						
1	2	4	2	6	3	4	5
2	2	3.5	1.5	7	2	6.5	4.5
3	1.333333	3.333333	3.666667	4.666667	1.666667	4.333333	3.333333
4	1	3.25	3.25	3.75	1.5	3.75	4
5	2	3.2	3.8	4.6	2	3	4.6
6	1.833333	3.5	0	4.5	3	3.5	4.333333
7	2.714286	3.142857	0	5	3.142857	0	3.714286
8	2.5	0	0	5.25	3.75	0	0
step length	forward relative difference quotient						
1	9	9	9	9	6	4	9
2	1000	5	8.5	1000	1000	4	7.5
3	1000	1000	6.666667	1000	1000	4	1000
4	1000	1000	5.25	1000	1000	1000	1000

Table 4. Relative difference quotients of different steps for new feasible solution

step length	forward relative difference quotient						
1	2	4	2	0	3	4	5
2	2	3.5	1.5	0.5	2	4	4.5
3	1.333333	3.333333	3.666667	3	1.666667	4	3.333333
4	1	3.25	3.25	3.25	1.5	5.25	4
5	2	3.2	3.8	4.2	2	4.2	4.6
6	1.833333	3.5	0	4.666667	3	3.833333	4.333333
7	2.714286	3.142857	0	0	3.142857	3.285714	3.714286
8	2.5	0	0	0	3.75	3.625	0
step length	forward relative difference quotient						
1	9	9	9	8	6	4	9
2	1000	5	8.5	7	1000	1000	7.5
3	1000	1000	6.666667	7.666667	1000	1000	1000
4	1000	1000	5.25	1000	1000	1000	1000

Table 5. Relative difference quotients of different steps for new feasible solution

step length	forward relative difference quotient						
1	2	4	2	0	3	4	4
2	2	3.5	1.5	0.5	2	4	2.5
3	1.333333	3.333333	3.666667	3	1.666667	4	3.666667
4	1	3.25	3.25	3.25	1.5	4	4.5
5	2	3.2	3.8	4.2	2	5	4.2
6	1.833333	3.5	0	4.666667	3	4.166667	3.5
7	2.714286	3.142857	0	0	3.142857	3.857143	0
8	2.5	0	0	0	3.75	3.375	0
9	0	0	0	0	0	3.666667	0
step length	forward relative difference quotient						
1	9	9	9	8	6	1000	5
2	1000	5	8.5	7	1000	1000	7
3	1000	1000	6.666667	7.666667	1000	1000	6.666667
4	1000	1000	5.25	1000	1000	1000	1000

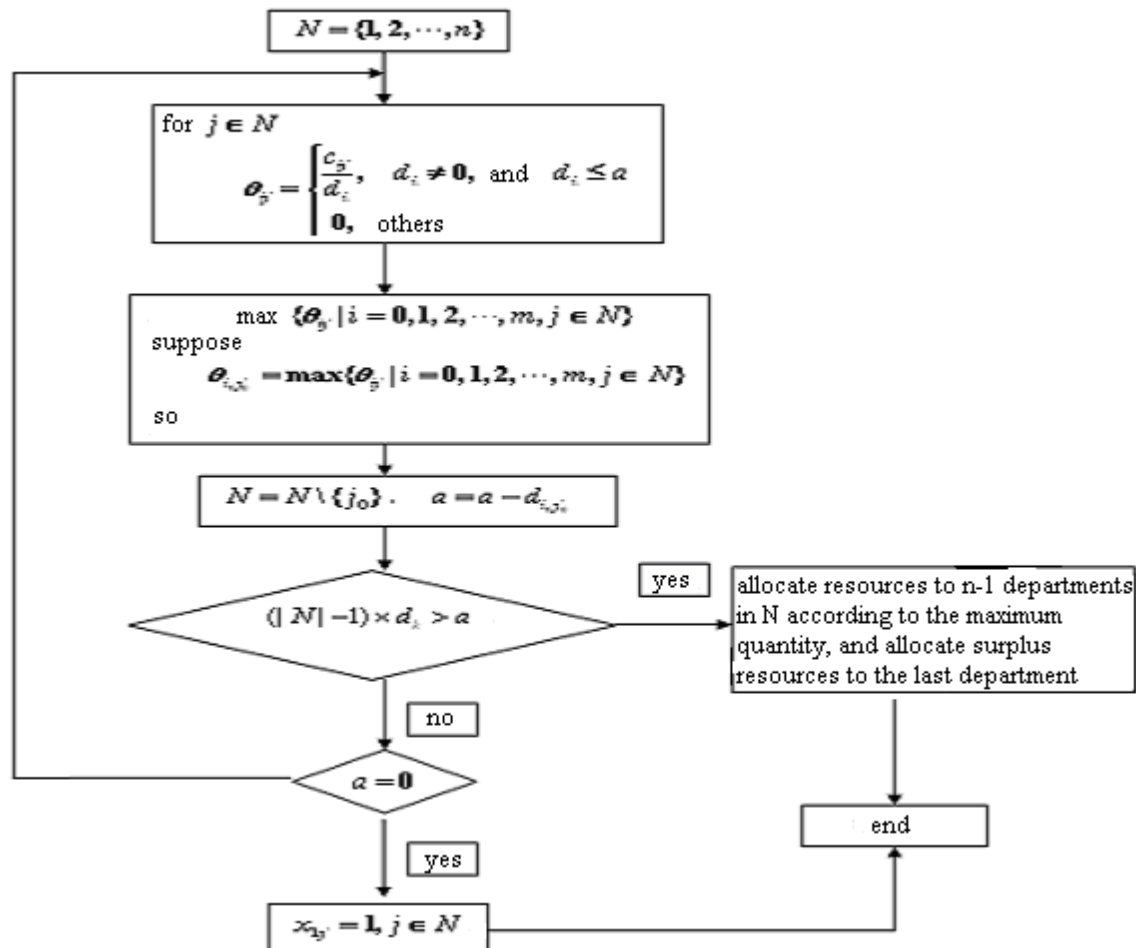


Figure 1. Computation Block Diagram of Initial Project

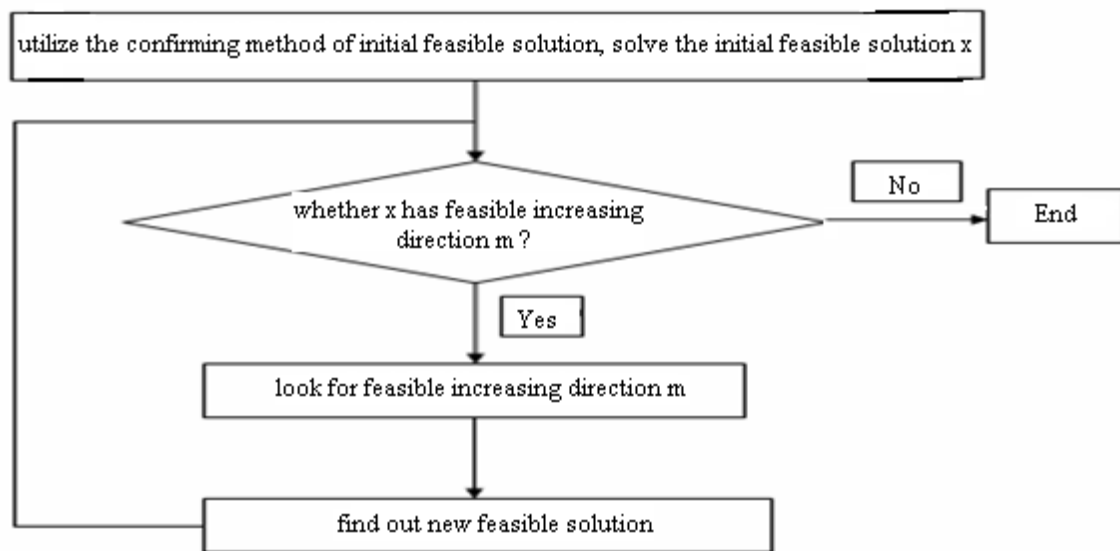


Figure 2. Computation Block Diagram of Special Solution



Management Strategies for a Seawater Intruded Aquifer System

Madhavi Ganesan

Assistant Professor, Centre for Water Resources

Department of Civil Engineering

College of Engineering Guindy, Anna University

Chennai-600 025, India

Tel: 94-4451-1425 E-mail: madhaviganesan@yahoo.com

S.Thayumanavan

Retd. Professor, Centre for Water Resources

Department of Civil Engineering

College of Engineering Guindy, Anna University

Chennai-600 025, India

The research is financed by the Council of Scientific and Industrial Research, Government of India, New Delhi

Abstract

Groundwater flow and solute transport in the coastal aquifer of Chennai are simulated using the United States Geological Survey three dimensional model MODFLOW and MT3D and feasible groundwater pumping and recharge strategies are identified and quantified to control the seawater intrusion.. Steps involved in applying the theoretical model to the field conditions are explained in detail. The model is calibrated, tested and projected for the period 1976 – 82, 1983 – 1996 and 1997 – 2020 respectively. Response of the aquifer for various pumping and recharge patterns are presented.

Keywords: Calibration, Simulation, Prediction, Confined aquifer, Seawater intrusion, Reclamation

1. Introduction

Chennai, the capital city of Tamil Nadu State, is the fourth largest metropolis in India. During the last three decades the city achieved a phenomenal growth in industry. This situation has led to increase in population and consequent demand for water. Prior to 1965, the entire water need of the city was mostly met from surface sources such as Poondi Reservoir, Cholavaram Tank and Red Hills lake. Since 1968, more than one third of the water demand was met by groundwater from three wellfields known as Minjur, Panjetty and Tamaraipakkam wellfields of Chennai Aquifer situated about 40 km North, North-West of Chennai (Fig. 1). The wellfields lie along a buried channel formed by the course of a perennial river that existed in the past. The wellfields are listed in the order of their proximity to the Bay of Bengal. Of the three, the Minjur wellfield lies nearest to the Bay of Bengal, at a distance of 9 km from the coast and it is hydraulically connected with the sea. This wellfield has been intruded by seawater since 1969 due to extensive extraction of groundwater for agricultural, industrial and domestic uses for prolonged periods of time that causes deterioration in the quality of the precious groundwater resource. After groundwater developments started, fresh groundwater flow from the aquifer to the sea has reversed. Groundwater flow and transport models are applied to assess the present aquifer conditions and to predict future aquifer situations in order to prevent further intrusion of seawater and to reclaim the contaminated aquifer.

2. Hydrogeology and Hydrochemistry

The Minjur-Mouthambedu Aquifer System MMAS is underlain by formations of quaternary, tertiary and upper Gondwana as well as by the basement complex of crystalline rocks. Gondwana rocks are covered by the extensive stretch of alluvium that forms the aquifer in the study area. The alluvium consists of gravel, fine to coarse sand, clay, silt, clayey silt and silty clay. The aquifer system is conceptualized as a two-layer system with an upper and lower formation, separated by an aquitard. The upper formation is an unconfined aquifer, which is directly connected to the rivers Korattalaiyar and Araniyar. The lower formation is a confined aquifer capped with clay beds and connected to the upper aquifer by vertical leakages. The permeability of the MMAS varies from 5×10^{-4} to 1.21×10^{-3} m/s from east to west. Central portion of the aquifer is highly porous having higher ranges of permeability.

The recharge to the unconfined aquifer is from rainfall and irrigation return flow. The recharge to the confined aquifer is longitudinal and exposed parts of lower aquifer. The withdrawal of water for irrigation, industrial and domestic uses are mostly from the confined aquifer. The fifty years average annual rainfall from the year 1944 to 1993 is 1377 mm. The years 1968 and 1982 had very low rainfall of 710 and 782 mm respectively. Most of the annual rainfall (58%) occurs during the north east monsoon period between October and December and 35% of rainfall occurs during the south-west monsoon period between June and September.

The piezometric trough was at a distance of 4.9 km from the coast during the years 1969 to 1975 and it moved to 6.5 km in 1977 and continued upto 1982. This movement is due to shifting of pumping wells from 4.9 to 6.5 km and it moved to 10.5 km in 1987. The trough was at depths -7.9m, -10.2m, -15.0m, -18.7m and -20.1m in the years 1977, 1982, 1987, 1990 and 1994 respectively. The movement of trough was due to the change in the position of pumping which is due to the deterioration of the quality of water. The freshwater-seawater interface position is fixed at the point at which the chloride bicarbonate ratio is more than one. It is found that the interface was at 2.4 km from the coast in 1969 and same was at 10.5 km from the coast in 1996.

3. Previous studies

Progressive depletion and pollution of the groundwater has been taken place by the virtue of supplying large quantity to the city of Madras now called as Chennai, resulted from the lack of proper groundwater management during the development of civil and industrial settlements in this area between 1960 to 1990. In order to provide sustainable aquifer management, numerical models are used. Models are valuable tools to assess the present aquifer conditions, to predict future aquifer situations and is used to establish remedial action plans to attenuate the groundwater quality deterioration. Most of the aquifers have thick mixing zone generated by freshwater and seawater dispersion. No longer the concept of sharp interface model is valid to describe the nature of the seawater encroachment. Cooper (1959) was the first to develop a hypothesis that under dynamic conditions the saltwater is not static but circulates perpetually from the floor of the sea into the zone of dispersion and back to the sea. A steady state solution for the flow field of interacting freshwater and seawater including the effects of dispersion in an idealized, rectangular confined aquifer was obtained by Henry (1960) by means of Fourier-Galerkin double series expansion. His results confirmed the existence of saltwater circulation in coastal aquifers. But this numerical scheme was unable to predict the encroachment for large Peclet numbers describing the actual field conditions of Biscayne aquifer (Kohout, 1960). Gupta (1982) and Bredehoeft (1973), Gupta (1986), Chapelle (1986), Mercer et al. (1986), AL-Layla et al. (1988), Rao and Hathaway (1989), Akindunni et al (1995) applied their density constant solute transport models to large scale field problems. In addition Pinder and Frind (1972), Frind (1980), Voss and Souza (1987), Huyakorn et al. (1987), Kakinuma et al. (1988), Sherif (1988), Anderson et al. (1988), Galeati (1992) and Xue et al. (1995) applied their variable density solute transport models to the fields. They simulated the system and predicted the nature of the system behaviour.

Fully 3-D saturated-unsaturated flow and transport models Panday et al. (1993) give the most appropriate simulation possibilities of these problems. However such model consume significant computation time to simulate large-scale flow and transport problems, which usually require meshes with large number of elements or grid blocks. To circumvent these difficulties, the dimension of the equations is reduced to quasi 3-D formulations. Several authors have developed quasi 3-D models for flow for heterogeneous multiaquifer systems. Bredehoeft and Pinder and Cooper (1970) considered the hydrological system represented by aquifers in which flow is assumed horizontal and by confining layers in which flow is vertical. The aquifers are coupled by leakage through aquitards. Hence the problem was reduced to solving 2-D equations for each aquifer. Herrera and Rodarte (1973) used the same assumptions and developed a model for leaky aquifers presented by a system of integrodifferential equations. This approach reduced the dimensionality of the problem and effectively uncoupled the equations corresponding to each of the aquifers.

Oldenburg and Pruess (1995) expressed that coupling of the flow and transport through density is essential only when the density variations are more than five percent. The variation in density between fresh groundwater and seawater is about two and half percent. The interface movement in Minjur-Mouthambedu Aquifer System is mainly due to over tapping of groundwater. A critical data analysis shows that the effect of over tapping groundwater has more effect than the effect caused by density contrast. Based on the aquifer analysis and from the knowledge of previous research it is decided to apply the quasi three dimensional density constant model to the MMAS.

4. Simulation of seawater movement

A three dimensional finite difference groundwater flow model MODFLOW (McDonald et al. 1988) and MT3D (Zheng, 1990) of U.S.Geological Survey are used to simulate groundwater flow and solute transport in the MMAS. The preconditioned conjugate gradient method is used to solve for hydraulic heads. Linear or nonlinear flow conditions can be simulated. The MT3D transport model uses a mixed Eulerian – Lagrangian approach to the solution of the three dimensional advective-dispersive-reactive transport equation. MT3D is based on the assumption that changes in the concentration field will not affect the flow field significantly. This allows to construct and calibrate a flow model independently. After a flow simulation is complete, solute transport model retrieves the calculated hydraulic heads

and various flow terms saved by flow model. The solute transport model simulates changes in the concentration of miscible contaminants in groundwater considering advection and dispersion. The physical phenomena occurring in the seawater intrusion process are represented as partial differential equations. These equations require certain simplifying assumptions to arrive at analytical solution. But real life problems does not satisfy these assumptions. These difficulties have paved way for the development of numerical models. Many assumptions must be made in order to apply the numerical model to field problems as discussed in following sections.

4.1 Assumptions

For the flow in the aquifers of large horizontal extent and small thickness, the variations of the groundwater head in a vertical direction are so small that can be neglected, which leads to a vertically averaged equation. In the present analysis, only the confined aquifer is considered. The recharge to the aquifer is mainly leakage through the aquitard, which is due to pressure difference in the water table and in the piezometric head. The movement of the solute is assumed to be horizontal and groundwater flow is assumed not affected by the presence of salt in the solution. The density and viscosity of the groundwater are assumed constant.

4.2 Boundary Conditions

Model boundaries are selected and located to approximate the natural hydrological boundaries of the groundwater flow system. The western boundary (landside) of the model is flow boundary calculated from Darcy's equation. On the land side boundary the concentration is constant and is equal to that of freshwater concentration C_f . On the sea side, constant head boundary is assumed subjected to hydrostatic pressure distribution. On the sea boundary, seawater concentration is C_s . No flow of water and salt are assumed laterally because the aquifer ends at the northern and southern side of aquifer system. The bottom of the aquifer is impermeable i.e., the normal flux through the bed for both fluid and salt is equal to zero. The top of the aquifer is assumed as a recharge boundary through which water leaks into the aquifer. Five piezometers are considered in a critical zone and two in the northern and southern side of the critical zone. The critical zone is a highly permeable zone resulting into high pumping that causes reduction in piezometric pressure which encouraged seawater intrusion into the fresh groundwater.

4.3 Discretization of the Space and Time Domain

To simulate the groundwater flow and solute transport with the numerical model, the aquifer is divided into nodal blocks of 250 m and 1000 m as a longitudinal dimension and 300m and 900 m as a lateral dimension. It covers approximately an areal extent of 320 square kilometres and 15 km long in east-west direction and 27 km wide in north-south direction. Certain cells are taken as inactive cells at which there is no flow of water and salt. The discretization is based on stability criteria as explained below.

Both finite difference and Finite element methods suffer from numerical damping and dispersion errors. Most numerical schemes generate computational errors near source points and sharp gradients (fronts). It is the growth of the numerical dispersion errors which give rise to the generation of wave packets of concentration (negative and positive regions resembling waves). Complex flow regions are often regions with high gradients and large numerical errors. The basic idea behind grid adaptations is to increase the number of grid points in regions of high gradients and reduce the number of grid points where the flow is smooth thereby increasing both the solution accuracy and speed of convergence.

The accuracy of the numerical solution is controlled through constraints on the grid discretization by means of the Peclet and Courant number criteria (Freeze and Cherry, 1979). The peclet criteria, which constrain the spatial discretization, is

$$P \equiv \frac{(V * \Delta x)}{D_x} \leq 2$$

Where

P	Peclet number
V	Seepage velocity
Δx	Spatial increment in x-direction
D_x	Longitudinal dispersion coefficient

The Courant criterion, which constrain the time discretization, is,

$$C \equiv \frac{(V * \Delta t)}{\Delta x} \leq \frac{P}{2}$$

Where

C	Courant number
V	seepage velocity
Δt	Time increment
Δx	Spatial increment in x-direction
P	Peclet number

The stability requirements for numerical schemes are to be met out. In single time step the fluid moves a distance equal to $(V * \Delta t / n)$. The physical interpretation of the stability requirement is that the distance moved by the fluid in any time step will be less than Δx , Δy or Δz or in other words, that the outflow from the cell in any time step will be less than the volume of water in the cell at the beginning of the time step. If the stability requirement of the time step is not met, the calculated solute concentration oscillate with each time step and sometimes result in negative concentration too.

The domain is subdivided into six subdomains and each subdomain is divided into a number of rectangular elements. The rectangular elements are smaller in the regions where the variation in the concentration gradient is relatively high. An intensive grid is provided near the sea boundary. The time is discretized into 30 days for the flow model. But, for the solute transport model, the time is discretized into 10 days. The space discretization is same for both the flow and transport model.

5. Model Application

Saltwater movement in the aquifer is simulated with the help of conceptual and numerical model. The conceptual model is developed with the information of geology, hydrogeology and physical parameters of the Minjur-Mouthambedu Aquifer System. Then the conceptual model is translated into numerical models such as flow and solute transport model with the model parameters and boundary conditions. Flow model simulates flow velocities and the transport model quantifies the migration of a contaminated plume within the aquifer. Models compute response variables such as head and concentration. These response variables are compared with field measurements of the same properties. When the simulated response variables approximate the measured response variables, the numerical model is considered to be approximation of the modeled aspects of the flow and transport system and the conceptual model of the aquifer. Simulated heads and concentration should be similar to the measured heads and concentrations. This may occur rarely on the basis of the initial estimates of the aquifer properties. After the initial simulation, the parameters in the model are adjusted to produce better agreement between simulated and measured variables. This process is known as 'Calibration' requires various steps and is discussed in the following sections. Good agreement can be achieved by specifying proper aquifer properties and realistic boundary conditions. The aquifer is simulated under transient state system and the physical parameters recharge, discharge and salinity distribution are assigned to every cell of the model. There are three steps involved when the theoretical models are applied to the physical system. They are

- i. Initial conditions and Calibration;
- ii. Testing the Calibration;
- iii. Future projection;

5.1 Initial Conditions and Calibration

Calibration is the process by which parameters in the model that represent aquifer properties are adjusted to produce good agreement between model response variables and measured properties. Calibration is needed because of uncertainties in formulating the conceptual model of the aquifer and because of measurement uncertainties associated with the determination of the aquifer properties. Calibration reconciles these uncertainties, providing the model parameters are adjusted within reasonable ranges. Some aquifer parameters are known with more precision than other parameters and during calibration those aquifer parameters with small uncertainties are either adjusted or not. The calibration process consists of adjusting the recharge and discharge rates for the flow model and dispersivity for the solute transport model to match simulated heads and concentration with measured values. The goodness of fit is measured by the Mean Difference (MD) and Mean Percentage Error (MPE) between measured and simulated heads and concentrations. During the calibration process the MD and MPE are reduced by adjusting the aquifer parameters such as permeability, storage coefficient, leakage and pumping rates. In this process, first the MD and MPE is reduced for the head using flow model. After achieving a reasonable accuracy the MD and MPE for concentration is reduced by adjusting the dispersivity using the solute transport model.

5.1.1 The computation of the initial head distribution involves the following steps

- Step 1. As a first step to arrive at the initial condition, the model is run with seven years (1976-82) average inflows and outflows and the resultant contour of piezometric heads are compared with the average of seven years observed piezometric heads.
- Step 2. The spatially distributed seven years average inflows and outflows data are taken and the model is run under steady state for which initial condition and storage coefficient values are not required.

- Step 3. With the same data used in step 2, the model is run under the transient condition. The steady state head contour obtained from step 2, is taken as initial condition. The actual storage coefficient is multiplied by 10^{-7} in order to obtain the steady state initial condition.
- Step 4. The model is run with the actual storage coefficient under transient condition. The head contour obtained from step 3, is taken as initial condition.
- Step 5. The parameters such as leakage and irrigation abstraction are adjusted till the computed head contour matched closely with the observed seven years average head contour.
- Step 6. To get the steady state condition, the model is run many times by substituting the final head contour of the previous trial as the initial condition of the current trial until the change in the head contour is negligible. The purpose of this step is to arrive at the predevelopment condition of the system.

In this study, the model is calibrated using the data pertaining to the period 1976-82. The initial estimates of aquifer parameters and boundary conditions are adjusted until the model is capable of simulating the historical hydrologic condition of the period 1976-82. The end condition is used as the initial condition for the period 1983 through 1996.

- Step 1. Seven years (1976-82) monthly average inflows, outflows and piezometric head contours are considered for calibration of the model.
- Step 2. The head contour arrived from the section in step 5 is used as an initial condition. With this initial condition, the model is tested first for the January month. The ensemble average head contour for the month of January is compared with the model result.
- Step 3. Through many trials the physical parameters are adjusted and improved to get a better match with the ensemble average head contour of January. The simulated piezometric head contour of January is the initial condition for the month of February. Again through trials the physical parameters are adjusted to get a match for both January and February. This process is continued for remaining ten months.
- Step 4. After finalising the aquifer parameters, to get the steady state condition, the model is run for many times by substituting the head contour at the end of December of the previous trial as the initial condition (January) of the current trial till the change in the head contour is negligible.
- Step 5. The head contours developed at the end of December in Step 4 are used as a starting head distribution for the calibration period 1976-82.

The model is allowed to simulate the calibration period with step 4 head distribution. The model is considered to be calibrated only when the difference (error) between the observed and simulated head is 0.3 to 1.0 m depending upon the position of the well. If the observation well is near pumping well the allowed error is 1.0 m otherwise 0.3 m. Till a good match is arrived the other parameters like vertical leakage and irrigation pumping are adjusted.

Either recharge or discharge can be fixed and the other quantity is to be adjusted to produce a simulated head distribution that matches the observed head distribution. Early in the process of modeling the MMAS, a decision is made to hold the irrigation pumping constant and to vary vertical leakage to produce a good match between measured and simulated response variables. After getting the better match, the leakage rate is kept constant and the irrigation pumping is calibrated to produce agreement between measured and simulated heads better than the previous one. To get good starting head distribution, which represents the previous history, it has undergone 106 trials in a PC-AT 486 machine with a speed of 66 MHz which has taken 12 minutes CPU time to run each trial.

5.1.2 Establishment of initial concentration distribution involves

Once a satisfactory hydrologic model is obtained, the mass average flux of fluid estimated from the hydrologic model was used in the mass transport equation to simulate the chloride distribution. The physical domain considered for regional simulation is the same as that used for the flow analysis. In addition to the flow pattern, to simulate saltwater movement it is required to have an appropriate boundary and initial conditions and the variation of porosity and dispersivity of the medium on a regional scale. High chloride concentration area, particularly in areas already contaminated, is inadequate to assign appropriate initial condition. This aspect is being considered as another adjustable parameter in the simulation of salt movement. Usually the first approximation of the initial chloride concentration distribution in the contaminated area is done through the consideration of one-dimensional transport along selected streamlines. Depending upon the flow system, the values of dispersivity and porosity can be critical to the modeling purpose. Measurement of dispersivity on a regional scale is difficult. In aquifers consisting of sand and gravel, porosity can be considered uniform on a regional basis and is expected to be in the range of 0.3 to 0.45. The simulated solute transport is not sensitive to porosity values in this range.

Steady state simulations are performed using various boundary conditions to evaluate the sensitivity of the system to these changes. The resulting chloride concentration is similar to the required initial condition, because of the uncertainty in the predevelopment chloride concentration. Although the model is used initial conditions that represented a steady state flow

and transport, the actual field conditions are probably not at steady state. The chloride concentration is assessed by the steady state flow and transport is kept as the initial concentration and it is tried to bring the 1976 initial condition by varying the dispersivity alone without changing other parameters. The dispersivity is tried in the range of 100 m to 1000 m.

After establishing the initial concentration distribution for the year 1976, the solute transport model is used to simulate the calibration period 1976-82. If it is not able to produce a better match between the observed and simulated concentration, then the parameter dispersivity is adjusted. Only up to 1000 m dispersivity the present system is sensitive, beyond which there is no significant change. Hence it is tried for various initial conditions. It is found that the aquifer system is very sensitive to initial concentration distribution. By trial and error, attempts are made to minimize the error. In this process, 52 trials are attempted to arrive at a minimum error. After calibrating the solute transport model for the period 1976-82, it is used for testing the calibration for the known period 1983-96.

5.2 Testing the Calibration

Once the aquifer parameters are calibrated, their validity should be confirmed by testing the system with data which are not used for calibration. For this purpose, normally the known time series is divided into two parts as calibration part and test part. In this study the calibration part is from 1976 to 1982 and the test part is from 1983 to 1996. The calibrated parameters are tested by simulating the system for which the head and concentration contour records are available. The computed head and concentration contours for December 1982 are taken as the initial conditions for January 1983 and the system is tested using the model for the years 1983-96.

5.3 Simulation Results

1) The calibrated hydraulic conductivity, specific storage and dispersivity are in the range of 80 to 160 m/day, 10^{-7} to 10^{-5} per m and 100 to 1000m respectively. The porosity is 0.4. The average leakage and irrigation pumping are calibrated as 23 mcm/year and 30 mcm/year respectively.

2) The percentage error for the piezometric heads in the critical zone is approximately four percent and near the production wells are about 12 percent. Higher error is due to draw down and radius of influence of the production wells. The MPE for the concentration is approximately ten percent in the critical zone.

3) Figure 2a and 2b indicate the match between the simulated head and concentration with observed head and concentration in the critical zone. The observed concentration is higher than the simulated concentration during the period 1986 to 1996 as shown in figure 2b. It is tried to match with various initial, boundary conditions and dispersivity. These extreme points must be due to some other local contaminations which cannot be simulated in the regional modelling.

4) It is found from the head contour that the piezometric pressure reduced from -12 m (1976) to -27 m (1988) and it increase to -12 m in 1991 and further improved to -9 m in 1996. The piezometric pressure head ranges between -12 m and -17 m during 1976-82, -11 m and -27 m during 1983-90 and -8 m and -15 m during 1991-96. This indicated that the pumping is maximum during the period 1983-90. The shape of the contours are entirely changed after monsoon, i.e. the critical zone is separated from the southern zone of the aquifer. The river recharges the southern zone and the water flows to the critical zone due to a head gradient and geological setup. There is rapid improvement in the piezometric pressure after monsoon. Seawater flows into the aquifer at the central zone and the freshwater outflows to the sea at the southern zone after the monsoon. The contours before monsoon indicated that the seawater flow to the aquifer is through the entire sea boundary.

5) The 1000 mg/l isochlor occupied 6.84 km from the coast from 1976 and it moved to 7.30 km in 1981. This is due to concentrated pumping and low rainfall. It suddenly moved to 11.2 km in 1983. There was a heavy rainfall of 2000 mm (above normal) rainfall at the end of the year 1983. Before 1983, the city demand was met by groundwater pumping at Minjur during the period 1982 to October 1983. As the Minjur was overstressed, the front suddenly moved to 3.7 km inland. Even though there was a heavy rainfall in the year 1983, it was not able to move back the front. After that the front was under a slight regression because of good rainfall in subsequent years (except 1993) and reduction in the irrigation pumping and industrial pumping. Finally the 1000 mg/l isochlor front occupied 9.95 km in 1996.

Table 1 shows the average leakage, irrigation pumping, industrial pumping, total pumping, seawater intrusion quantity, salt inflow, minimum piezometric head, chloride concentration and the position of 1000 mg/l contour for the period 1976-82, 1983-90 and 1991-96. The MMAS behaved separately in the three periods. The aquifer was overextracted during the period 1983-90 compared to the other two periods 1976-82 and 1991-96. Even though the aquifer was overpumped during the second stress period (1983-90) the rate of seawater intrusion was more in the first period (1976-82) because of low rainfall and sudden increase in the pumping. This sudden pumping created high depression in the piezometric surface which invited the front suddenly to 11 km from the coast. Even though the rainfall was more in the subsequent years and reduction in the total pumping, it was not able to move back the front to the position occupied during 1980's.

6. Seawater Movement for Hypothetical Pumping Situations

Seawater encroachment in coastal aquifers will definitely be controlled with the reduction and rearrangement of groundwater withdrawals or the injection of freshwater and maintenance of freshwater ridge above mean sea level. Moving back saltwater interface towards the sea is simulated from 1997 through 2020 for the following situations.

Scenario 1. No change in 1996 groundwater withdrawals*

Scenario 2. 10 percent increase in 1996 Groundwater withdrawals

Scenario 3. Elimination of groundwater withdrawals for Industrial uses**

Scenario 4. Elimination of groundwater for Irrigation uses***

Scenario 5. Elimination of all groundwater withdrawals

Scenario 6 Optimal groundwater withdrawals

Scenario 7 Optimal groundwater injection

* Total pumping in 1996 was 34.17 mcm per year

** Industrial pumping in 1996 was 3.4 mcm per year

*** Irrigation pumping in 1996 was 30.77 mcm per year

Five observation wells are considered for the simulation that lie in the critical zone. The other two observation wells are situated in the north and south to the critical zone. Which have not been affected significantly. In brief, the area upto 6.5 km named first trough was affected heavily during the crucial years (1983-90). The deterioration of quality of water at 6.5 km, forced to construct 32 pumping wells between 9 km to 13.5 km. named second trough. In addition to irrigation pumping, nine to eleven mcm per year was pumped for drinking water from this zone. This created deeper trough between 9 to 13.5 km than the trough at 6.5 km. For the future projections, the observation well 6 (at 6.5 km from coast) is considered as critical well and all the discussions are with reference to it. The simulated results are used to find the system's behaviour for the future. The system is projected and annualized for the period 1997 to 2020 as future period. The head and concentration contours at the end of December 1996 is taken as initial condition at the start of 1997 and the system is projected for the future. Demand and rainfall recharge are the data to be given for future years. The rainfall data is assumed cyclic and the past records are used for the future.

6.1 Comparison of Scenarios 1, 2, 3, 4, 5, 6 and 7

Scenario 1: If the 1996 pumping rate of 34 mcm per year is continued for the future years the fluctuations in the piezometric head reaches dynamic equilibrium and the frontal movement is somewhat controlled (Fig. 4a). However the concentration increases exponentially at 6.5 km from the coast due to development of deep trough formed during the period 1976 – 1990 (Table 2).

Scenario 2 : If the pumping rate is increased by ten percent of 1996 pumping rate the 1000 mg/l front moves towards the land by about 1.36 km and the chloride concentration increases exponentially to about 15500 mg/l at 6.5 km (first trough) from the coast. The piezometric pressure head reduces to 15 m below MSL at the end of 2020 (Table 2). The main reason for increase in chloride concentration at first trough is due to concentrated pumping at the second trough.

Scenario 3 : The elimination of three million cubic metre of industrial pumping at second trough moved back the 1000 mg/l by one kilometre and the head improved from –8 m to –4 m at the end of 2020 (Table 2)

Scenario 4 : The elimination of irrigation pumping, 30.77 mcm/year moved back the front 1000 mg/l by about 3.5 km and the concentration reduced to about 670 mg/l at the first trough at the end of 2020 (Table 2).

Scenario 5 : As all the groundwater withdrawals are eliminated, the front is retreated back by about 3.7 km (Fig. 4b) and the concentration reduces to nearly 600 mg/l at the end of year 2020 (Table 2).

Scenario 6 : Optimal pumping rate is the pumping rate at which meets applied restrictions and maintains the piezometric head above mean sea level. Optimal pumping rate is 72 percent of 1996 pumping which is amounted to 24.6 mcm/year. If the pumping is cut down by 28 percent per year the front would have retreated back by about 1.5 km (Fig. 4c) and the concentration reduced to 3783 mg/l at the end of 2020 (Table 2).

Scenario 7 : Optimal injection rate is evaluated as 8.1 mcm/year which could move back the front by about 3.4 km (Fig. 4d) and reduced the concentration to 502 mg/l at the end of 2020 (Table 2).

7. Discussions

It is found that the variations of head reached dynamic equilibrium sooner than the concentration. The concentration either increased or decreased rapidly in the first ten years and the changes are slower in the next ten years. This indicates that the system reach dynamic equilibrium for concentration also. Through various simulation runs it is found that either by reducing the pumping rate or increasing the recharge rate or both will control and reclaim the aquifer. Reduction in pumping is possible either by changing the agricultural pattern or buying groundwater rights from the formers. Reducing the pumping is cheaper and sustainable solution. But it is very difficult to educate and control the formers. However if it is planned well it is possible to implement it. Other alternative is to recharge treated waste water into the contaminated aquifer. Every year minimum of 35 million cubic metre of waste water is treated which can be utilized for groundwater recharge. Another alternative is, every year 100 million cubic metre of water surpluses in the drainage basin of this aquifer. This can be used effectively. The entire length of the aquifer is 52 km, in which the confined aquifer becomes unconfined aquifer at 39th kilometre. At which reservoir called Thirukandalam reservoir exist which can be used for direct recharge into the aquifer instead of injecting it under pressure.

8. Summary And Conclusions

Freshwater for Chennai city has been supplied by wells withdrawing from the MMAS and also to the near by towns and industries since 1965. The withdrawals of groundwater have caused water levels decline in the confined aquifer over a broad area forming a cone of depression in the potentiometric surface centered at 6.5 km from the coast. Flow in the aquifer that had previously towards the sea has been reversed and as a result seawater has moved slowly towards the land. Chemical analysis from observation wells indicated that a transition zone has been under transient condition. The MODFLOW and MT3D model of the USGS are used to simulate groundwater flow and solute transport of the MMAS. Model is calibrated for the period 1976 – 82 and is simulated reasonable movements of saltwater for the period 1983 – 96. The solute transport model is particularly sensitive to permeability, discharge and recharge rates, the initial concentration distribution and to the longitudinal dispersivity. The accuracy of the solute transport simulations is related, primarily, to the availability and accuracy on these characteristics and particularly on heads and solute concentrations in the aquifer. The solute transport simulation indicate that the transition zone would continue to move toward land even if same pattern of 1996 withdrawals are followed. But reduction in withdrawals or the injection of freshwater or treated waste water may reduce the movement toward the land according to the simulation.

References

- Akindunni, F.F., Gillham, R.W., Constant, B. Jr. and Franz, T. (1995). Modelling of contaminant near pumping wells: Saturated-Unsaturated flow with particle tracking. *Ground Water*, Vol.33, No.2, pp. 264-274.
- Al-layla, R., Yazicigil, H. and Jong, R.D. (1988). Numerical modelling of solute transport patterns in the Dammam aquifer. *Water Resour. Bulletin*, No.1, pp. 77-85.
- Andersen, P.F., Mercer, J.W. and White, H.O. Jr. (1988). 'Numerical Modelling of Saltwater intrusion at Hallandale. Florida, *Ground Water*, Vol.28, No.5, pp.610-630.
- Bredehoeft, J.H. and Pinder, G.F. (1973). 'Mass transport in flowing groundwater. *Water Resour. Res.*, No.1, pp.194-210.
- Chapelle, F. (1986). A solute transport simulation of brackish water intrusion near Baltimore. Maryland, *Ground Water*, Vol.26, No.3, pp.304-311.
- Cooper, H.H.Jr. (1959). A hypothesis concerning the balance of freshwater and saltwater in a coastal aquifer. *J.Geophys.Res.*, No.64, pp.461-467.
- Frind, E.O. (1980). Seawater intrusion in continuous coastal aquifer-aquitard system. Proc.3rd Int.Conf. Finite Element Water Resources., Univ.of Mississippi, Oxford, Miss., Vol 2, pp.177-198.
- Galeati, G. (1992). Coupled and partially coupled Eulerian-Lagrangian model of freshwater-seawater mixing'. *Water Resour.Res.*, Vol.28, No.1, pp.149-167.
- Gupta, A.D. and Yapa, P.N.D.D. (1982). Saltwater encroachment in an aquifer: As case study. *Water Resour.Res.*, Vol.18, No.3, pp.546-556.
- Gupta, A.D. (1986). Simulated Saltwater movement in the Nakhon Luang aquifer. Bangkok, Thailand, *Ground Water*, Vol.26, No.4, pp.512-522.
- Henry, H.R. (1960). *Saltwater intrusion into coastal aquifer*. Int.Ass.Sci.Hydrol.publ., No.52, pp.478-487.
- Herrera, I. and Rodarte, L. (1973). Integrodifferential equations for systems of leaky aquifers and applications. 1. The nature of approximate theories. *Water Resour. Res.*, No.9, pp.995-1005.

- Huyakorn, P.S., Anderson, P.F., Mercer, J.W. and White, H.O. (1987). Saltwater intrusion in aquifers: Development and testing of a three dimensional finite element model'. *Water Resour.Res.*, No.23, pp.293-312.
- Kakinuma, T. and Kishi, Y. (1988). The behaviour of Groundwater with dispersion in coastal aquifers. *J.Hydrol*, No.25, pp.225-248.
- Kohout, F.A. (1960). Cyclic flow of saltwater in the Biscayne aquifer of southeastern Florida. *J.Geophys. Res.*, No.65, pp.2133-2141.
- McDonald, M.C. and Harbaugh, A.W. (1988). MODFLOW, A modular three dimensional finite difference groundwater flow model. U.S.Geological Survey, *Open-file report*, pp.83-875.
- Mercer, J.M., Lester, B.H., Thomas, S.D. and Bartel, R.L. (1986). Simulation of saltwater intrusion in Volusia County. Florida, *Water Resour.Bulletin*, No.6, pp.951-964.
- Oldenburg, C.M. and Pruess, K. (1995). Dispersive transport dynamics in a strongly coupled groundwater-brine flow system. *Water Resour. Res.*, Vol.31, No.2, pp.289-302.
- Panday, S., Huyakorn, P.S., Therrien, R. and Nichols, R.L. (1993). Improved three-dimensional finite element techniques for field simulations of variably saturated flow and transport. *J. Contam. Hydrol.*, No.12, pp.3-33.
- Pinder, G.F. and Cooper, H.H.Jr. (1970). A numerical technique for calculating the transient position of the saltwater front. *Water Resour.Res.*, No.6, pp.875-882.
- Pinder, G.F. and Frind, E.O. (1972). Application of Galerkin's procedure to aquifer analysis. *Water Resour.Res.*, No.8, pp.108-120.
- Rao, B.K. and Hathaway, D.L. (1989). A three dimensional mixing cell solute transport model and its application. *Ground Water*, Vol.29, No.4, pp.509-516.
- Sherif, M.M., Singh, V.P. and Amar, A.M. (1988). A two dimensional finite element model for dispersion (2D-FED) in coastal aquifers. *J.Hydrol.*, Vol.10, No.3, pp.3-22.
- Voss, C.I. and Souza, W.R. (1987). Variable density flow and solute transport simulation of regional aquifers containing a narrow fresh water-saltwater transition zone. *Water Resour.Res.*, No.23, pp.1851-1866.
- Xue, Y., Xie, C. and Wu, J. (1995). A three dimensional model for seawater intrusion in China. *Water Resour.Res.*, No. 4, pp.903-912.
- Zheng, C. (1990). MT3D, A modular three dimensional transport model. S.S.Papadopoulos & Associates, Inc., Rockville, Maryland, pp.1-150.

Notations

MMAS	Minjur – Mothambedu Aquifer System
2-D	2-Dimensional
3-D	3-Dimensional
USGS	United States Geological Survey
C_f	Freshwater Concentration
C_s	Seawater Concentration
MD	Mean Difference
MPE	Mean Percentage Error

Figure Captions

Fig. 1	Study area and its location
Fig. 2a	Comparison of observed and simulated piezometric heads in the critical zone
Fig. 2b	Comparison of observed and simulated chloride ion concentration in the critical zone
Fig. 3	Simulated 1000 mg/l isochlor contours for the Period 1976-96
Fig.4a	Projected isochlors at an interval of 1000 mg/l for scenario 1
Fig.4b	Projected isochlors at an interval of 1000 mg/l for scenario 5
Fig.4c	Projected isochlors at an interval of 1000 mg/l for scenario 6
Fig.4d	Projected isochlors at an interval of 1000 mg/l for scenario 7

Table 1. Summary of simulation results

Year	1976-82	1983-90	1991-96
Leakage mcm/year	13.36	27.94	27.34
Irrigation abstraction mcm/year	20.68	34.50	31.42
Industrial supply mcm/year	11.65	9.56	5.02
Total pumping mcm/year	32.33	44.06	36.44
Seawater intrusion mcm/year	18.91	16.74	9.22
Salt inflow Tonnes/year	550.00	380.00	140.00
Piezometric head w.r.to MSL (m)	-14.71	-20.50	-12.00
Chloride concentration mg/l	1366.00	3490.00	8133.00
Position of 1000 mg/l contour km	7.16	10.90	10.28

Table 2. Summary of results of all the seven scenarios at the end of 2020

Initial Piezometric head at the critical zone was -8.0 m;

Initial Chloride concentration at the critical well was 8329 mg/l;

Initial position of the 1000 mg/l Isochlor was 9.95 km from the coast.

Scenes	Piezometric Head (m)	Chloride Concentration (mg/l)	Position of the front (km)	Net distance moved (km)	Seawater intrusion quantity (mcm)	Net Salt Flow (mkg)
Scene 1	-10	13810	9.79	-0.16	131	4.5
Scene 2	-15	15503	11.31	1.36	222	7.25
Scene 3	-4	12458	8.98	-0.97	97	3.6
Scene 4	+32	670	6.42	-3.53	-236	-5.8
Scene 5	+32	606	6.18	-3.77	-756	-5.7
Scene 6	+7	3793	8.44	-1.51	-120	0.95
Scene 7	-4.65	502	6.56	-3.39	-62	0.50

Negative sign indicates that the flow of water and salt out of the aquifer to the sea.

Negative sign for the net distance moved indicates the frontal movement to the sea.

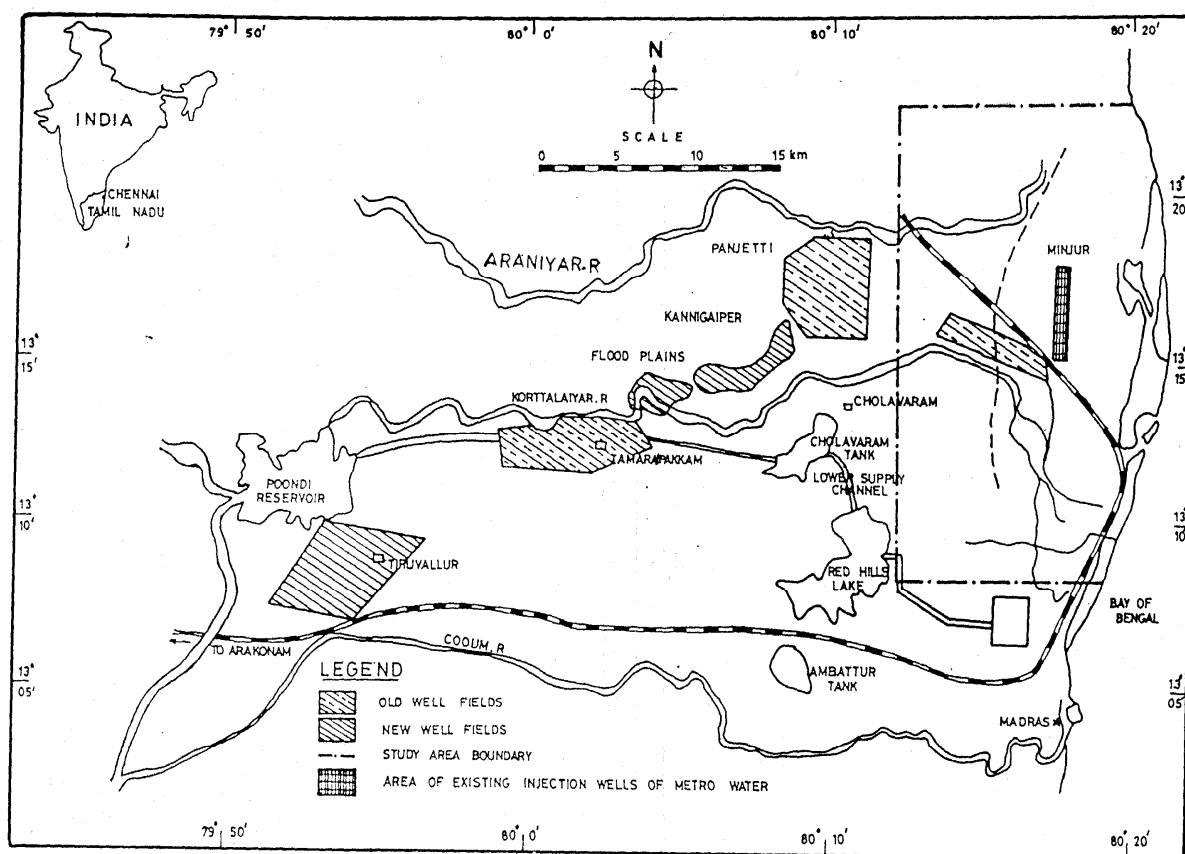


Fig. 1. Study area and its location

Fig 2a Comparison of observed and simulated heads in the critical zone

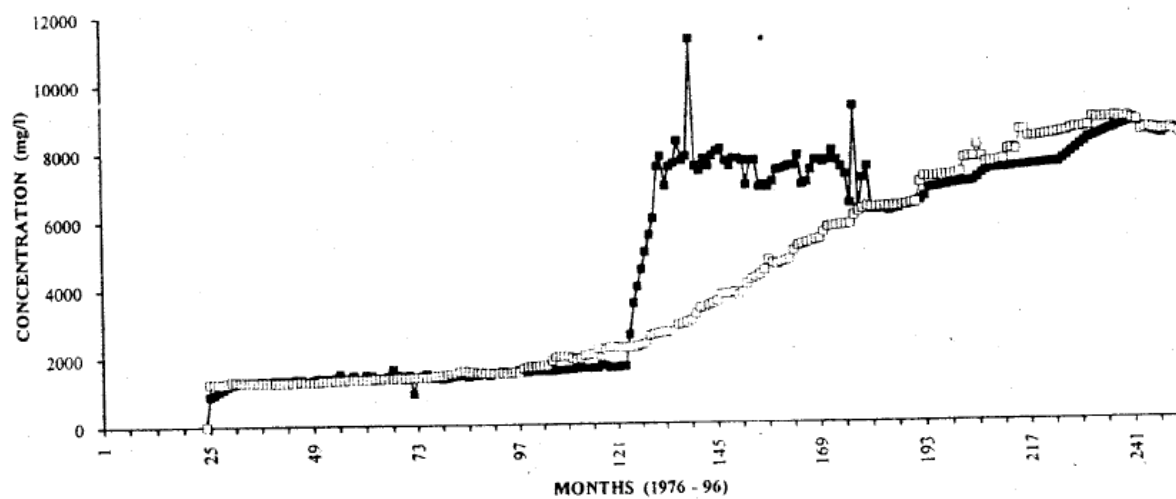


Fig 2b Comparison of observed and simulated chloride ion concentration in the critical zone

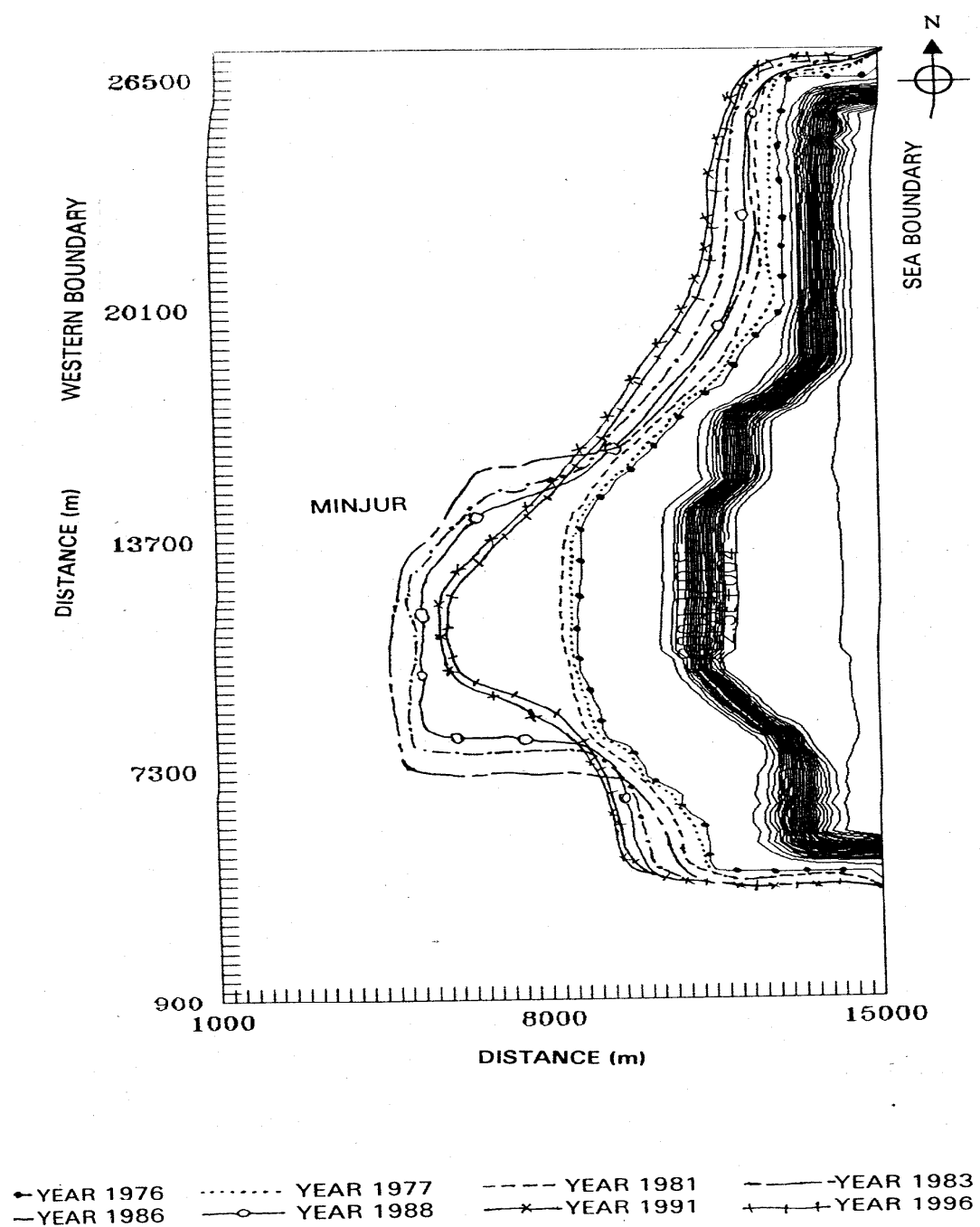


Fig. 3 Simulated 1000 mg/l isochlor contours for the period 1976-96

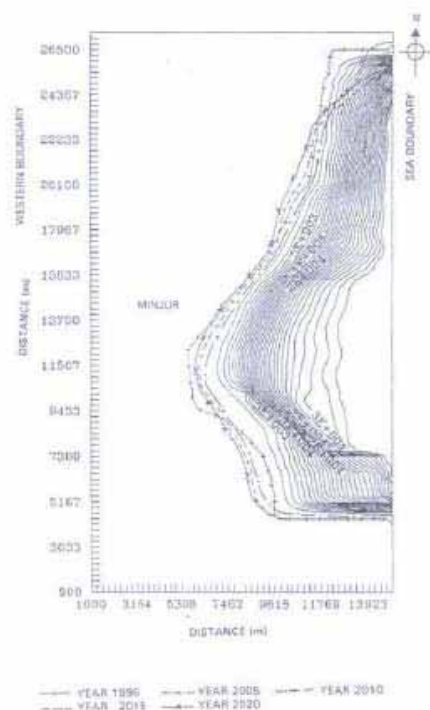


Fig. 4a Projected isochlors at an interval of 1000 mg/l for Scenario 1.

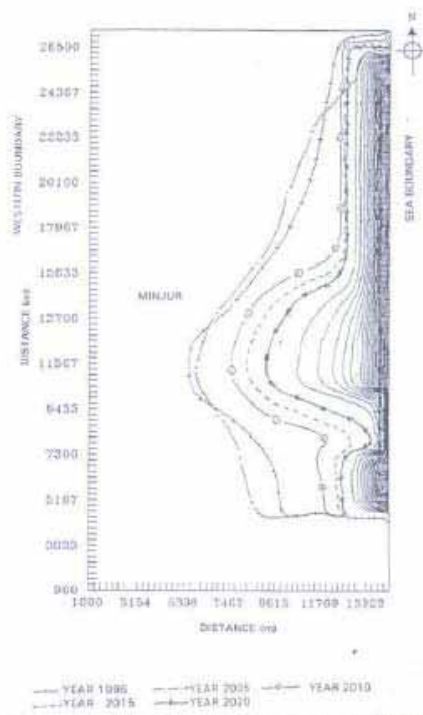


Fig. 4b Projected isochlors at an interval of 1000 mg/l for Scenario 5.

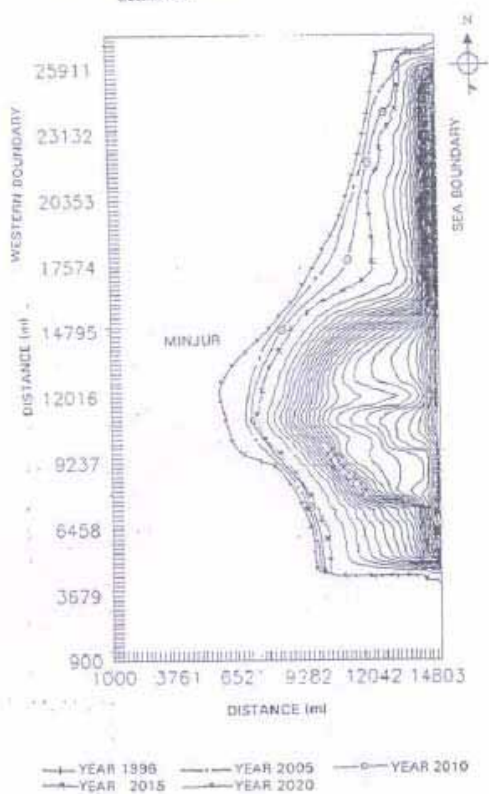


Fig. 4c Projected isochlors at an interval of 1000 mg/l for scenario 6.

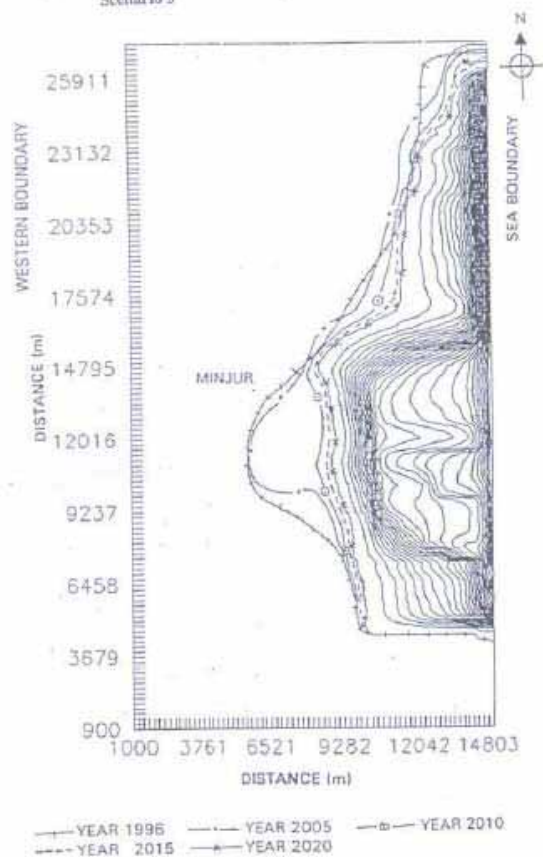


Fig. 4d Projected isochlors at an interval of 1000 mg/l for scenario 7.