What drives change? A framework to observe and understand broad-scale change in river basins

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Synopsis:

Development in river basins is strongly influenced by a range of non-random factors, called global drivers. These can present a bewildering array of effects that confound concerted action. This report summarizes these effects with the CPWF's six basins and presents a method of visualizing them together within a process of scenario visualization.

1. Introduction: Why examine "global drivers"?[1]

African rising: Identifying drivers from the narrative

A recent article in the Economist journal describes the rise of Africa from the 'global problem'of a decade ago to the 'hopeful continent' today. The narrative is loaded with facts that reflect the influence of global drivers on African economies.

The main type of driver observed, naturally enough for this journal, are economic. It notes, that over a dozen countries experience annual growth rates of over 6.5%, that the middle class – defined as people earning over $3,000 a year - is set to grow to over 100m by 2015. That external trade has increased by 200% in10 years, that productivity is increasing by 2.7% a year and that trade within the continent has increased from 6% to 13%. Furthermore, it notes that, unlike previous 'false dawns', this growth is not dependent on resources, which account for only about one third of the growth.

Economic drivers are not the only changes reported. Dramatic changes are reported in demographic indicators, which have seen a major decline in infant mortality, resulting in a median population age of 20 years. Population is expected to double to 2 billion and while some hope is expressed about the possibility of reaping the 'demographic dividend', fears are also expressed about potential for catastrophe if jobs are not created to absorb the young people the dividend implies.

Political change is seen as essential to success. The continent has seen major changes since independence, not all successful. Recent improvements in politics have seen democratization, a move away from Marxist politics (in Ethiopia and Mozambique) and a general, if somewhat patchy, progress towards transparent and representative politics.

It is interesting that in a journal that focusses on economic aspects, global climate change is mentioned explicitly, though not in detail. Climate change is likely to be a major factor determining the sustainability of agriculture within the region as economies move towards industrialization.

Finally, technology is also mentioned as a major factor in development, particularly the huge penetration of mobile phones (with 600m subscribers) and the possibilities this opens for micro-finance, novel health care and agro-enterprise development.

The value in describing the drivers is as follows: Clear explanation of the factors that deliver a society to its current condition helps understand how societies within river basins find themselves in a given condition, and help predict what is likely to happen in the future. Decisions of investment and politics refer to such insight.

Within the CWPF we are concerned specifically with the conditions of global food and water systems, and the interaction of these with development. Analysis concludes that while it is reasonable to express concerns concerning the availability of natural resources, sufficient resources exist to support development through to 2050, if (and only if) they are managed differently. Specifically, the changes needed are through greater long-term investment to improve productivity, greater sharing of benefits and risks, all based on an underlying collective political discourse. Such changes are profoundly influenced by drivers such as those described above. The purpose of this

[1] An introduction can be found at: http://www.slideshare.net/CPWF/introduction-to-global-drivers-cpwf-gdtwg-workshop-september-2011

framework is to assemble information regarding the condition and influence of these drivers in basins, and to remove some of the uncertainties facing the Basin Development Challenges.

We organize this in the following sequence:

In **section 2**, we describe some of the drives, as proposed by participants at three meetings. In **section 3**, we assemble this information about multiple drivers within scenarios for each basin. **Section 4** describes the process of response, indicating the key uncertainties that prevent optimal change patterns. **Section 5** summarises these findings.

2. A short list of drivers

We briefly outline each of five drivers and provide links to presentations that explain the main concepts.

Economic

Economic activity can be considered as changes in demand and supply that connect what people do within basins with global or regional activities beyond the basin. Activity within basins generate demand that may be met by supply from outside. Conversely, activities outside the basin may stimulate supply from within.

The level of a nation's (or basin's) income is its GDP, which is the sum of all productive activities, or the total income, or the total of all consumptive activities. For comparison, it may be expressed as GDP per capita. An important characteristic of GDP is its growth rate. Many developing countries are maintaining growth rates of GDP in excess of 5%, while most developed countries have growth rates 2-3%.

The level of prices and their volatility of the commodities a nation imports or export controls the terms of trade. A nation's economic structure is determined by whether it depends on primary industry such as agriculture and mining, on secondary industry, or on services. Investment may comprise capital inflows and outflows as well as domestic investment. There is invariably heterogeneity, between regions, between rural and urban communities and between groups within a community.

Economic activity of a nation (or a basin) is affected by:

- Globalization (global liberalization of trade) and bilateral free-trade agreements ;
- Protectionist policies;
- Hidden subsidies;
- Currency parity (the Economist's big Mac index);
- Financial crises; and
- Corruption, which is a hidden cost that affects many developing countries.

Population and demography

The main controls on national populations are the birth and death rates. It is commonly accepted that the driver of high birth rates is the rate of child mortality, so that when it falls, there is an immediate, voluntary decrease in fertility as measured by the mean number of children per woman. The time lag between decline of mortality and fertility describes the period of maximum population growth. In China, some parts of S.E. Asia and Latin America, fertility rates are at or close to replacement. In India increase is still strong, and expected to remain so for the next twenty or thrity years. In Africa, fertility rates remain very high. UNEP predicts strong population growth for the coming decades.

Migration occurs both internationally and within a country. It has two components, out migration and in migration. Within countries it is exemplified by an almost universal migration from rural areas to cities. It may be spontaneous as in many countries, or caused directly by civil unrest in rural areas, as in Colombia and Peru. The major question is who migrates and why?

Population structure is related to demography. As fertility declines, often within one generation, countries experience a demographic transition in which there are fewer dependent on the working population. The result is known as the demographic dividend, exemplified by East Asia in the last 30 years and possibly starting in some African countries at present.

HIV/AIDS has had profound effects on population structures in many African countries over the last 40 years and –together with the growth of urban employment in some regions- has also resulted in the strong 'feminization' of African agriculture. This has profound implications for the future development of agriculture.

Dense populations, as in China and India, put increased pressure on land and water resources. The institution of inheritance has important influence on the division of land. Primogeniture ensures that the entire estate is passed to the first born, while equal inheritance leads to the subdivision of land into smaller and smaller plots.

Demographic, social, and economic drivers are described at:
http://www.slideshare.net/CPWF/demog-social-econ-eric-kemp-benedict

Politics

Political discourse occurs at the national and local level. Politics underwrites the formation and working of institutions which influence, for example, individualistic or collaborative behaviours.

Political change is a current topic with the dramatic changes of the "Arab spring" consisting of regime changes in Tunisia, Egypt, and Libya and continuing unrest in Syria and several Gulf states. The final outcomes remain unclear (January, 2012), but the trend is to replace repressive authoritarian regimes with some form of elected government. There is internal civil conflict in Colombia in the Andes basins, and Pakistan in the Indus.

International dialogue is an important driver, with some successes, such as the 1987 Montreal Protocol on Substances that Deplete the OzoneLayer, while others such as the United Nations Framework Convention on Climate Change are less successful.

At the national level there is a need for a political discourse that recognizes the development processes in relation to the impacts on the ecosystem services that support it.

At the local level, politics underwrite the nature of arrangements between groups sharing resources.

For more detailed information about political drivers, visit:
http://www.slideshare.net/CPWF/political-drivers-cpwfgd-workshop-sept-2011

Global climate change

The important consideration is future variation in relation to current variability.

Temperatures will increase, more in absolute terms at high latitudes than in the tropics. Higher temperatures will increase evapo-transpiration, and in doing so will increase water demands. Higher temperatures will also have independent effects on plant performance, such as reduced pollination and in extreme cases, crop failure. Technical fixes may be possible for some crops, such as rice that

flowers earlier in the day to avoid damaging high temperatures at pollination, breeding beans that are less sensitive to high temperature damage of the pollen tube by crossing with species of beans that are less sensitive.

Rainfall may increase in the tropics and lessen in some temperate regions. There are also likely to be temporal changes with increases for a number of decades followed by decreases (or vice versa), which will require continuous adaptation on the part of farmers.

In practice, the main implications of climate change are likely to be:

- Shifts in growing environment of major crops as a consequence of increase in temperature and/or modified rainfall patterns. In some areas (e.g.. Southern Africa) these are likely to be substantial. In the Andes, the picture comprises both losses and gains.
- Changes in water balance, including increased incidence of extreme flood or drought events. Most of the basins studied are expected to experience increased rainfall, largely off-set by increased temperature. Of the ten basins studied by the BFPs, the Limpopo alone is expected to experience a substantial decline in rainfall and consequent decrease of flow.
- Increased uncertainty, partially as a result of greater variability of climate events. The practical effect of this is a constraint on long-term investment, additional obstacles to negotiated settlements over water resources, and disruption of emerging supply chains on which high productivity depends.

See "climate change and environmental drivers": http://www.slideshare.net/CPWF/climate-change-and-environmental-drivers-cpwfgd-workshop-sept-2011

Innovation and technology

These are two different concepts.

Innovation is bottom-up, influenced by the institutional structure of the community and its willingness to accept change. Innovation is an on-going process in which people adapt technologies to their own particular needs, and in doing so provide tailored solutions to local problems.

Technology is largely top down and in many instances is imported from outside the community. It relies on invention, which is different from innovation. Its influence can be profound as in the case of the rapid adoption of cellular telephones in developing countries. But not all technologies are readily adopted as in the case of genetically-improved maize varieties in Mexico.

Technological change: http://www.slideshare.net/CPWF/technological-change-cpwf-gd-workshop-september-2011

Drivers in Basins

The following presentations provide rich views of drivers in basins by scientists from the CPWF basin development challenges (BDCs).

Mekong: http://www.slideshare.net/CPWF/mekong-drivers-of-change-cpwf-gd-workshop-sept-2011

Volta: http://www.slideshare.net/CPWF/volta-drivers-of-change-cpwf-gd-workshop-sept-2011

Limpopo: http://www.slideshare.net/CPWF/limpopo-drivers-of-change-cpwf-gd-workshop-sept-2011

At IFWF3, November, 2011

Andes: http://www.slideshare.net/CPWF/gdtwg-session-posters-ifwf

Ganges:

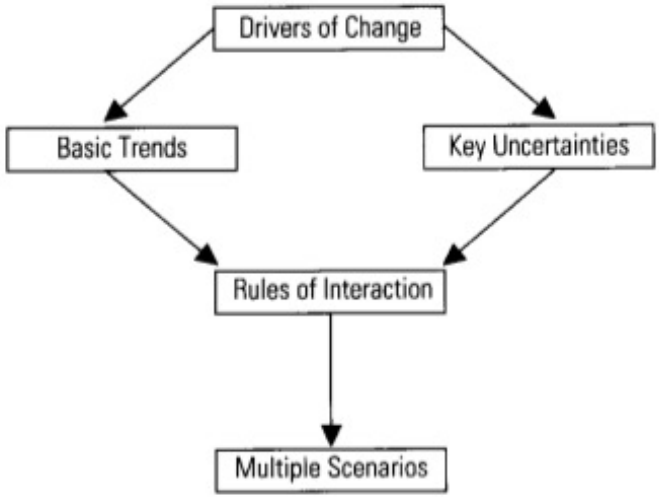
3. Building scenarios: How do drivers act together to impel change in basins?

Scenario methodology[2]

Scenario thinking is a **disciplined method of imagining possible futures** by identifying and combining known trends and uncertainties. The idea is not to try to predict the future (this would never give you any unsurprising scenarios), but rather explore the range of possible futures, irrespective of their probability. Scenarios can therefore be used to identify early-warning signals, indicators, or thresholds of negative outcomes. For the CPWF in particular, it can help us assess the robustness of our core competencies, generate better strategic options, and evaluate risk/return profile of options in view of opportunities.

We have decided to base our methodology on Shoemaker's step-by-step analysis of the FST process (see figure at the right).

Figure 2 Building Blocks for Scenarios



However, we chose to experiment with a much more visual version of it, which has the advantage of more creative pairings of trends and uncertainties. Our global approach allows for vastly different scenarios, each taking into account different stakeholders, trends, uncertainties, and wildcards, and weighting these factors differently. Moreover, our methodology produces outputs at each level that can be saved and even recycled/introduced in secondary FST exercises.

In our version, the group is facilitated towards identifying stakeholders (triangular cards), trends (rectangular cards) and then uncertainties or wildcards (circular cards). Trends are ongoing patterns that all unanimously agree will continue in the future, e.g. population growth in India. Uncertainties are best posed as questions regarding patterns that group members are unsure or disagree about, e.g. will biofuels become a major player in energy security? Wildcards are perhaps unlikely events that would be game-changers, e.g. an AIDS vaccine that could affect African population patterns and thus food demand. All these paper cards are color-coded by driver (blue = political/institutional, green = environmental, yellow = economic, orange = demographic/social, pink = technological)

After being given time to identify rules of interaction, quantitative evidence, etc., the group is then instructed to combine different shapes and colors to create cogent narratives of potential futures. As the factors the cards represent can play a greater or lesser role in a given scenario, they can be given numeric weights (1-5), which can be beneficial (+) or detrimental (-) towards the goal (for CPWF,

[2] More information on Future Scenario Thinking [FST] can be found at: http://www.slideshare.net/CPWF/introduction-to-future-scenarios-thinking-theory-and-exercise-cpwf-gd-workshop-sept-2011

water/food security). Summing the values of the different cards in a given scenario then give you a sense of how "good" or "bad" the overall scenario is for you (the CPWF). These scenarios are then re-checked for internal consistency, more research is done to provide better quantitative (or qualitative/anecdotal) support before final scenarios are produced.

At a small Global Drivers workshop with mostly BFP invitees, Charlotte Lau and Amanda Harding led a step-by-step scenario-thinking exercise. The workshop participants were split up into teams of two, representing 5 of the 6 basins. The groups were given about 3.5 hours to go through an abbreviated version of the exercise, with each team coming up with 2-3 different possible future scenarios. The group shared some of the scenarios at the end of the exercise, and received feedback. This methodology and the resulting scenarios were presented at IFWF3 in Pretoria in November, 2011.

While the workshop FST exercise proved the potential worth of this kind of exercise, it was clear that larger, more diverse groups would be needed to build more meaningful scenarios. Moreover, the facilitator ought to do more background research and supply these data to group members before the meeting. And lastly, with more people participating, more disagreement is to be expected, and it is likely that at least one full day would be necessary.

Scenario building: An example

We presented the following (simplified) example of NYC housing, where the focal question was: "How will rent costs and housing demographics look in 2020?" The exercise was conducted by an anti-gentrification NGO advocating affordable housing for the poor. According to the methodology, the following were identified:

Stakeholders:

- NYC housing authority
- NYC government
- New Yorkers today and potential (at all SES: lower-income, gentrifiers)
- Landlords
- CSOs

Trends:

- Gentrification
- City population growth
- Increasing cost of living and transport in general
- Security concerns (earlier: crimes, now: terrorism)

Uncertainties:

- Will wealthy non-natives continue to move in, willing to pay $$?
- Will rent control continue to protect affordable housing?
- Will outer boroughs move towards apartment-style housing, over houses?
- Will the economic crisis/housing crash continue to affect prices?

Wildcards:

- Series of really awful terrorist attacks that destroys the economy and prevents people from moving to NY

Rules of interaction:

- NYC legislature cares more about renters than landlords (likely to keep rent control). All trends interact together to push costs upwards, unless uncertainties mitigate.

Example Scenario:

4/5 colors, mix of trends (rect) and uncertainties (circles)
Total: -8 (realistic middle scenario)

Title	**The Bridge and Tunnel Answer**
Answering uncertainties Demographics Economics Politics / Stakeholder-poltn Demographics Landlord- stakeholder NGO mission – impact on poor Economics/ Innovation MTA –stakeholder Impact on other NYers	The economic crisis and security concerns have no real effect on people in-migrating to New York, and in fact only results in the wealthy coming. This pushes up the costs of all non-rent-controlled apartments. (Rent control remains, as Democrats remain in power.) Manhattan becomes fully saturated. As a result, gentrification continues. The Jehovah's Witnesses sell out their vast holdings in downtown Brooklyn, releasing significant land for apartments. The government pushes out well-located projects e.g. in Queens and lower Manhattan, to further out in Brooklyn or Staten Island (free ferry service). Poor communities move out to pockets of New Jersey and Connecticut, and increasingly live in over-stuffed apartment buildings in Staten Island, the Bronx, and distant Brooklyn. In response to housing demand, Queens turns increasingly to apartment-style housing over individual houses. The MTA raises transport costs to extend the subway to more neighborhoods in Queens, making this a viable option for commuters. This reduces the housing crunch, preventing rents from rising too much.

Scenarios from each basin

ANDES

"Worst case"

Continued global depression hits national economies in the region which have become dependent on minerals and off-farm income. Starved of revenue, resources for rural development are unavailable, leading to sustained under-investment in rural development. Rural areas become increasingly separated from urban areas. Urban unemployment remains stubbornly high, yet migration continues to urban areas, leading to disaffection and political unrest. Major upheavals in national politics follow, coupled with polarization regionally that leads to conflict between politicians [many populist], who swing hard to either left or right. FDI, the mainstay of economic growth is reduced. Opportunities for the green economy are frozen internationally and within country. Influence of environmental NGOs decreases, leading to poor practice and lack of control of FDI, which leads to abuses and risks to the environment and the rural poor who depend on it. Rural poverty worsens, pressure on the environment decreases but so does long-term investment and legislation on behalf of the environment also decreases.

Severe climate change impacts niche production areas, rural stakeholders who are dependent on these are unable to adapt. Increased variation of rainfall leads to greater risk of landslides, flooding and soil erosion.

"Best case"

Sustained growth of the economy, including mining, but coupled with growth of the green economy and which sustains the development of ESs [internal = water and external = biodiversity and C]. Growth of markets for ESs are enabled by proper valuation. Valuation of ESs enhances regulation and distribution of revenues. This also impacts the characteristic of FDI (including investment in mining). FDI is encouraged, leading to risks for ecosystems, but these are mediated by improved legislation and pressure from civil society.

Population growth slows. Improved investment in rural services and education supports population stabilization, though urbanization continues. Through expansion of supply chains for niche market, development of markets for ESs, rural prosperity improves. This is enhanced by improvements in access to ICTs and transport infrastructure.

Political stability, supported by successful international cooperation within Andean countries, including open markets underwrites a steady growth of high-value products. International policy reduces the incidence of illicit crops, leading to a decline of political violence.

Adaptation to climate change is enhanced by Improvements in governance, international cooperation and diversity in the the rural economy.

LIMPOPO

We thought that both scenarios would be found in the basin, due to climatic variability. They will play out in an interesting mosaic.

"Positive scenario"

Mining and industrialization leads to the continued feminization of agriculture. Industrialization and population growth leads to an increase in the demand for food, including meat and increasing land scarcity. Market opportunities for livestock products continue to increase at local, regional and

international level. Land scarcity and increased profitability lead to intensification and increased mechanization. Initial investments in mechanization are made from profits from livestock. The changes are supported by a political process that that brings in land reform that gives land to small-scale farmers, together with infrastructure development to improve links to market. Economic growth and market development is furthered by increasing SADC integration, in particular about infrastructure development and opening access to markets. LIMCOM gains traction allowing better and more equitable use of Limpopo water resources.
Will hold for SA, Bots and Zim, less for Moz

"Negative scenario"

In certain places climatic variability and reduced rainfall mean that agriculture cannot respond to market demand and the opportunity offered by livestock production. This is in part because of labour shortage due to out-migration to work in mines, HIV-AIDS, feminization of agriculture and an aging population. Reduced rainfall increases risk, which means investments in mechanization are not viable despite government promotion of labour saving solutions. Government investment goes to buy food from abroad rather than spending it on infrastructure or social security. Land reform is thrown at the problem, but this fails because of labour shortage and low returns to farming.
May not hold entirely for Moz

MEKONG

Scenario	1		2		3	
Power demand	Increases		Increases		Increases	
Dams	Get built		Get built		Get built	
Dams designed	Not fish friendly		Fish friendly/ sediment friendly/ plays well with others		Not fish friendly	
Downstream fisheries	Obliterated		Maintained		Obliterated	
Livelihoods changes	Remittances/ migration		Rural + urban mixed		Rural + urban mixed	
Corporatization of NR/farm/fish	Fairly full		Only partial		Partial and partly reversed	
Social unrest	Minimal		Minimal		All hell breaks loose	
Rise of civil society	Engaging – advocacy/ policy		Partnerships formed		Advocacy – violent protest	
Investment in infrastructure	Private		Private or public – DBs		Private	
Corruption	Skyrockets		Under control		Skyrockets	
Hydrology changes	Less pulsing, more dry season flows		Some pulsing, environmental flows		Less pulsing, more DS flows	
Demand for power collapses	ES not maintained		ES maintenance reduced		ES not maintained	
Nutrition	Less protein available for poor		More protein available		Less protein available for poor	
Final result	Surrender		Peaceful coexistence		Water war	

Comparison across 3 scenarios:

In three scenarios, power demand from Thailand and Vietnam are major drivers affecting the Mekong resulting in a sharp increase in hydropower development. In S1 and S3, dams designed for the Basin are not

fish friendly resulting in obliteration of the downstream fisheries. In S2, dams are built with innovative fish and sediment friendly technologies, enabling the maintenance of fisheries. Local farmers/fishers livelihoods continually change. In S1, remittances and migration factor strongly whereas in S2/S3, livelihoods are largely a mixture of rural and urban. The private sector control fish and farming in S1 and only partially in S2/S3. As a result, social unrest in S3 breaks out across the Basin. Whilst economic development has skyrocketed, civil society has continued to develop. In S1, civil society decides to engage with decision-makers and advocate for change. In S2, CSOs create partnerships and in S3 protest violently. Corruption is rampant in S1/S3 but maintained in S2 because of investment by the MDBs. Hydrologically, flood pulsing decreases; dry season flows increase and ecosystem services are lost. S2 sees some pulsing resulting in environmental flows and ecosystem services are maintained. The nutritional needs of society are of great concern, however not on the radar of investors. S1/S3 result in less animal protein availability, whilst in S2 more protein is provided due to environmental flows. In conclusion, a water war breaks out in S3; stakeholders in S1 decide to surrender, as none of their efforts have been successful. Stakeholders in S2 coexist peacefully and ultimately change the development trajectory of the Mekong.

"Scenario 1" (written out):

Power demand in Thailand and Vietnam leads to a sharp increase in hydropower development. Dams designed for the basin are not fish-friendly, resulting in the obliteration of downstream fisheries. Widespread private sector corporatization of fish and farming occurs. Local farmers' and fishers' livelihoods change, and remittances and migration factor in strongly. As the economy develops quickly, civil society does too—and CSOs begin to engage with decision-makers and advocate for change. Corruption skyrockets. Hydrologically, flood pulsing decreases; dry season flows increase, and ecosystem services are lost. The nutritional needs of society are of great concern, as less fish mean less protein available for the poor. However, as this does not seem to matter to investors, stakeholders decided to surrender the fight.

NILE

"Narrative 1. Best case scenario"

Foreign direct investment on sustainable hydropower development in cool upstream countries through building sustainable water storage facilities in the Nile will create the urgently-needed energy for local industries. FDI will promote benefit sharing and increase access to rural farmers, while creating water access for irrigation for downstream communities once power is generated . Local institutions will be strengthened and there will be an increased flow of knowledge and interventions. This is particularly relevant in situations where global climate change will increase temperatures and aggravate unproductive evapo-transpiration in warmer, downstream countries. This will have a positive implication on public-private partnership, but also farmers will start to adopt it recognizing the benefits. This will also facilitate environment friendly tourism, fisheries and other users, which could benefit the rural population and the wider public.

"Narrative 2. Worst case scenario"

In a context of regional power imbalances, and against a background of global economic uncertainty, FDI driven by self-interest leads to poor domestic economic development characterized by inequity and land grabbing. Food and fertilizer prices rise, while a Nile pact is far away. Countries strive for water security in a desperate attempt to keep control of this increasingly scarce resource. Domestic political instability is one 'response'. There is no effective responsive governance and water competition and scarcity increase, both up- and downstream and between different users. Farmers

cannot adapt, and deforestation and land degradation worsen. The result is one of increased poverty and inequality, and poor adaptation to climate shocks

VOLTA

" Too Hot – Too Crowded – Too Corrupt (climate variability, population growth and corruption)"

Consistent rise in temperatures and unpredictable rainfall patterns alongside 3% population growth in the basin force rural populations initially to marginal lands and increasingly into urban slum areas. This, coupled with acquisition of remaining productive land by foreign investors paying off government officials, see poverty increase greatly in the Basin over 40 years, despite NGO and researchers' continuing scattered projects.

" Finding alternatives: from gloom to glory"

Temporary urban migration imposed by basin stresses and shocks, raise the possibility of diverse livelihoods options, including access to micro finance, increased demand for alternative products and markets. These are facilitated by civil society initiatives and effective government and regional subsidies and so offset some of the impacts of climate variability.

" Regime Change – Resilient Communities"

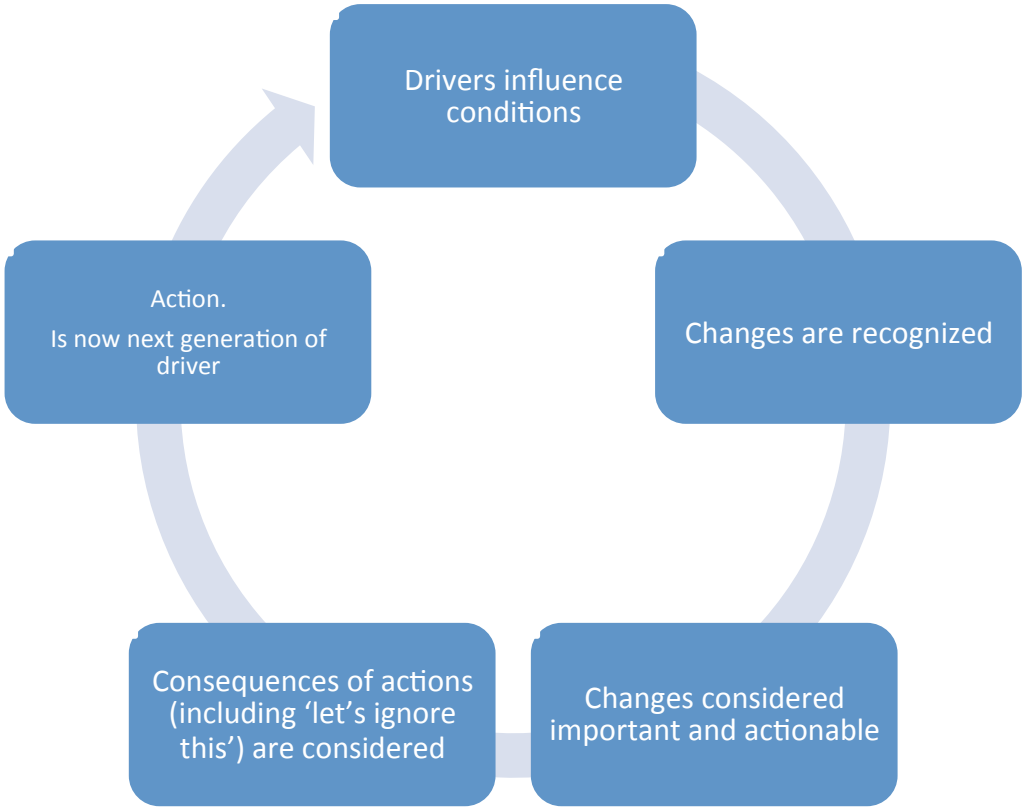
Following a period of instability, civil society and youth mobilises to bring about democratic representational government, seeing a shift in regional and foreign investment patterns as well as improved equitable Basin regulatory frameworks and resource coordination and conflict resolution structures. Small holders in rural areas mobilise themselves, improve productivity and their incomes seeing less imperative for urban migration.

"Innovative technologies"

Big dam development results in regulation of flows in the basin, economic growth and investment through energy exported across the region as well as increased irrigation complimenting small reservoirs. This in turn further supports small scale farmer-led technological inputs and helps diversify production, which buffers them from variations in commodity prices and the effects of climate change.

4. Responding to drivers: Deliberative processes of change

We now consider the deliberative response to drivers: what decision-makers do when they are aware of change in river basins. We consider the way people respond to global drivers to identify how research can support 'better' decision-making. We represent the process in the figure below.



The process of responding to drivers

Uncertainty prevents timely response:

Drivers act on conditions and change them. If the change process appears so simple, why does it not occur? People do not respond because of four different types of uncertainty: Is the change recognized? Is the change important enough to respond, and is response possible? What responses are appropriate and what are the consequences of these responses?

a). What drivers occur?

We describe six classes of drivers in section 2. This classification is relatively arbitrary and is based on the advice of specialists from the six river basins. In reality, the scope of drivers is infinite, affecting all aspects of social, economic and ecological activity.

b). Is change recognizable?

Many of the changes are recognized retrospectively, from evidence and inference. For example, climate change has been observed for decades, but its anthropogenic cause only relatively recently. All of the drivers described have been researched extensively. However, we know much less about their specific impacts, which consequently remain of unrecognized importance.

Analysis should clarify this recognition. However, recognition is a cognitive process that goes beyond the mere provision of information and requires the active engagement of critical stakeholders. This process resides clearly within the BDCs.

c) Is the change important and actionable?

Climate change is now recognized as a reality (almost) universally amongst senior politicians. Most, however feel unable to respond because of domestic political realities. Politicians from poorer countries are unable to respond, even if political realities permitted.

The realization that change is important nearly always depends on a long-term mindset because most major drivers are only perceptible over the longer term. FDI and food-price shocks appear to be the exceptions, but they are the consequence of long-term increases in food demand, combined with the lack of investment in agriculture.

d) What are the consequences of change?

Consider the Ganges delta, currently experiencing increases in salinity as a consequence of changes in flow patterns upstream, and rising sea levels as a consequence of global climate change. What will happen if nobody responds? When will problems become unavoidable? At what point will the polders cease to protect from sea level rise? Can the changes in water quality be exploited for prawns and rice in the same way that Vietnamese farmers do?

In all cases, the consequences involve people, different groups of people, some of whom have a political voice, some who do not. The consequences are viewed by politicians in relation to the perceived value of change. In the Mekong, changes to the livelihoods of the millions of people who relied on aquatic system were previously regarded as less valuable than the gains offered (to fewer people) by a massive expansion of hydropower. All such representations are value-laden. Clarity from objective analysis can improve the political process.

e) Does change make the system more resilient, or less resilient?

Responses to drivers may increase or decrease resilience. Who knows? For example, a policy response to revive flow in the Yellow River (see Ringler *et al.*, 2010) demonstrates an impressive ability to control a major water management system. Conversely the apparent inability of governments to control groundwater use by farmers in the Ganges (Sharma *et al.*, 2010) appears to imply serious loss of resilience. But which change is more resilient in thelong-term? As the presentations cited below show, conditions are rarely so simple, since they include many non-linearities and feedbacks. Prediction is difficult and frequently ill-advised, but a fuller understanding of the systems as described by resilience theory will at least ensure that the complete range of questions are asked.

Resilience of food and water systems: http://www.slideshare.net/CPWF/resilience-of-food-and-water-systems-cpwf-gd-workshop-sept-2011

Resilience thinking: http://www.slideshare.net/CPWF/resilience-thinking-cpwf-gd-workshop-september-2011

Basic points about the change process:

The decision to change or not change should take into account the following:

- Change is inevitable – even a lack of response results in change. All systems are partially open and dynamic. Ignorance of change, or a decision to 'do nothing' does not isolate the system from external influences but merely puts the system in a relatively worse condition.
- Change begets change: In a dynamic environment, responses to drivers themselves become drivers. Between 1960 and 2008, population growth has more than tripled population density in India from 99/km2 to 338/km2 with a consequent reduction in land area per capita. At the same time, population growth increased demand for food, and also created markets for water for those fortunate enough to maintain access. As the market developed, for example, higher value dairy products became more attractive.
- Drivers are external and internal. The difference between external drivers and their internal progeny can be indistinct. For example, massive increases in the demand for hydropower originated outside the Mekong basin but these give rise to other demands for food and land around the sites being developed for hydropower. Similar external-internal links can be seen in Ethiopia and Colombia with the development of high value chains for coffee.
- Change is multi-dimensional. Change affects many different attributes of a system, including income, resource condition and social capital. Not all are represented by conventional economic models. For example, development of mining industries in the Andes rapidly enhances income, but at the cost of water quality.
- Change does not affect all equally. Change tends to work through existing power structures. Those with power tend to benefit at the cost of the poor, who are without voice. This imbalance can be corrected by political processes, but normally only after a substantial time lag.
- Response is non-linear. Investment in the system can improve total productivity so that gain is positive. In the Indian Punjab, a massive investment in the agricultural system during the Green Revolution saw a substantial increase in total factor productivity of irrigated systems. Conversely, lack of change from this trajectory now increases the risk of rapid decline of water availability because of unsustainable use of ground water leading to loss of resilience.
- Decision processes are highly uncertain. All aspects of the decision process are beset by uncertainty: the influences themselves are often unclear, especially in their early stages when decisions can be most effective; the interactions amongst drivers, for example between population pressure and climate change, add further uncertainty; the consequences of response are less so; the social and political implications of change (or lack of it) encourage a 'do nothing' mentality.

5. Summary table

Basin	Economic	Population/demographic	Political	GCC	Inn &techmp;pg
Andes	Mining resource boom	Low population increases for the past 20 years. Rural depopulation. High rates of urbanization	US-dominated policies of 70s and 80s being replaced by politics that recognizes indigenous rights. Regional specializations.	Biodiversity loss. Some changes of glacial melt.	
Ganges	India economy exerts major pressures through demands for energy	Bangladesh birth rates low. India remains high.	Water policies 'hijacked' by special interests of select farm groups	Rise in sea level a major threat in the delta.	Monitoring?
Limpopo	Strong local markets from industrialization. Surge in mining puts extra demands on water, but also a major employment opportunity.	Exodus of young farmers leaves farming in hands of an aging population. Feminization of agriculture as a result of HIV and labour migration.	SADC regional politics needed to harmonize policy.	All models indicate major reduction of rainfall by 2050. Poses major threat to cropping and reduced flows in an already water-scarce basin	
Mekong	Major demand for hydropower from 'dragon economies' of China, Thailand and Vietnam.	Moderate population growth. Increasing discrepancy between rich and poor; rural-urban migration.	Democratization still in process in some countries.	Uncertain impacts on river flow.	Internet democracy?
Nile	Increasing connection with international trade. HP an emerging opportunity. FDI inland and in water	Rapid population growth. Birth rates in Ethiopia remain high.	Major changes in Egyptian regional dominance. Increasing acceptance of Ethiopia. Kenya and Uganda emerging from the shadow. Major demand for institutional underpinning of change.	Major threat to sustainability of rainfed systems. Land degradation seen as a widespread problem.	Micro-finance?
Volta	Increasing influence of external markets. FDI in land and water. Oil and gold major movers in Ghana	Major pressures from increased population in Sahel and gulf region. Migration.	Regional integration.	Huge uncertainty of impacts influences investment environment.	Micro-finance. Telecommunications

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