**Logic Table to address Sustaining Human Habitation of the Planet relative to the threat(s) associated with Climate Change**

**Preamble**

*An overwhelming majority of scientists, governments and the public agree that there is significant risk associated with global warming and that efforts to limit warming to under 2 degrees Celsius will be essential to avoid unacceptable outcomes. This document does not address any precise targets but instead examines the logical components of a solution which may allow the achievement of any target and also to address actions needed to cope with change. (Note that this approach tries to scope mitigation and adaptive actions, given that changes are occurring whether or not we can measure or predict them precisely or model specific outcomes) It can serve as a menu regarding the range and relevance of possible interventions. Mitigation actions will address reducing the production of fossil fuels or reducing their negative impacts while adaptation actions are what is needed if/when mitigation fails and act to remove or reduce the negative effects on the planet and its residents.*

| **Element** | **Mechanisms** | **Methods** | **Assumptions** | **Measures to address Assumptions** | **Potential actor(s)** | **Role for Public,** | **Potential CACOR action** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mitigation** |  |  |  |  |  |  |  |
| GHG reduction via reduced extraction of fossil fuels | Reduce extraction of fossil fuels | Fuels left in earth  Slow exploration  Regulations to prevent dirty extraction or limit amounts,  Exploitation and development costs increased | New tech replaces need for energy  Governments reward less GHG or regulate  Market for fossil fuels diminishes (in face of alternatives?)  Governments will set aside some sites | Research, support for new tech, information, sharing of new tech widely  Subsidies, taxes  International accords signed and implemented  Limit exploitation on crown land | Coal and petrol producers  Government regulators, marketplace | Reduce demand by personal choices  Demand government action  Lobby industry to change via NGOs | Do position papers to politicians and the public outlining why this is needed and options to make it happen. |
| Reduction of production and use of other damaging substances | Reducing production of e.g. methane, nitrous oxide, hydro-fluorocarbons, perfluorocarbons, and sulphur hexafluoride. | Substitution, reduction of loss, capture of emissions, improved techniques to mitigate at source. Cap use. | New tech can find suitable substitutes and industries will accept them. | Research, support for new tech, information, sharing of new tech widely.  Include these in international accords | Coal and petrol producers  Government regulators, marketplace | Reduce demand by personal choices  Demand government action  Lobby industry to change via NGOs |  |
| Decoupling | Less contamination per GHG consumed | New means to Cburn with less release of GHG | New tech leads to efficiencies of use  Users will and can employ new methods | Research, support for new tech, information, sharing of new tech widely  Subsidies, taxes | Utilities, refiners, end users  Government via incentives disincentives | Choose products of firms with good environmental record. Demand public reporting corp. record | Periodic technology reviews. and reviews of corporate reporting. |
| More product per unit used | Production efficiency | New methods mean more from less energy | Improved methods are found to meet needs  Consumers will accept change | Private sector  Consumers (see below) | Demand energy efficient products  Support labelling of energy footprint of each product |  |
| Substitution | Consumers will select for low energy options if they are developed and are affordable | Users can be convinced that green is better- information on alternatives, removal of subsidies on high carbon products  Subsidization of alternatives | Producers and consumers  Government via rule setting and subsidies for substitutes | Lobby for new products which are low energy and for subsidies for them  Demand removal of subsidies for inefficient ones | CACOR could do periodic technology reviews. |
| GHG Impact reduction per unit of energy used | Cleaner forms of fossil fuels  (as a transition or stopgap… will this delay more to better options?) | Shift to natural gas, other less harmful fuels (Which are most acceptable?)  Require cradle to grave analysis of footprint of each energy source | Gas, means to remove carbon safely from fuels becomes common, economic  Trade agreements do not preclude differential tariffs, or discrimination with regard to pollution | Technology used to remove carbon, other substances at source or before release.  Trade agreements amended to allow ability to favour clean energy production | Companies in extraction and refining, factories, utilities  Trade ministries | Lobby, choose purchases based on energy footprint, demand that footprint is listed |  |
| Biofuels | Algae, crop biomass, | Options create less GHG (net) than alternatives.  Negative effects on other uses not extensive | Cradle to grave analysis of these options | Tech firms, agricultural sector.  Research agencies | Invest in these options and demand that others (insurance companies, pension funds etc) do as well | CACOR could be involved in doing or commissioning tech reviews alone or with Council of Canadian Academies |
| Renewables | Hydro power – large and small systems | Negative effects on ecosystems controlled  Efficient use of power from systems | Power scheduling and grid sharing to reduce need to supplement flow with fossil sources for peaks | Electric utilities | Lobby utilities for renewable energy sources |  |
| Tidal and ocean current/ use of temperature differentials | Cost effective methods to extract are improved | Research, investment in new tech | Utilities, some off grid users – lodges, coastal communities | Visit properties with alternative energy sources |  |
| Wind power | barriers to installation, removed, subsidize until economic?  Demo projects | Cradle to grave analysis of real benefits, costs, impacts by third party | Landowners, power companies, public demand | Choose enterprises with alternative energy sources, lobby for removal of barriers and opposition |  |
| Geothermal sources | Large scale district heating, single dwelling links (also heat exchangers could qualify) | Demo projects, third party benefit/cost | Town planners, government regulators | Lobby for use of these sources where feasible |  |
| Solar collectors | Improvement of cost per unit.  Public opposition to impact can be addressed. New uses/structures can be made less visually and spatially invasive | Visuals can be managed (some nanotech solutions)  Collectors on existing structures  Subsidies of various kinds | Solar industry, (many new players in Canada and abroad)  Regulators, individual building owners | Lobby for removal of barriers to use  Buy and use where feasible.  Favour enterprises using such sources |  |
| Nuclear | Existing reactors | Safe and secure use, acceptable waste disposal. Retrofit costs not excessive relative to alternatives | Public is informed regarding risk and benefit in believable way.  Safe disposal of waste arranged and accepted | Current nuclear utilities, current regulators | Demand objective cradle to grave assessment re sustainability and risk |  |
| New reactors (next gen types) | Improved reactors with safe systems, lower costs.  Tech and suitable fuel sources are available | Public is informed regarding risk and benefit in believable way.  New nuclear fuel sources sought. | Nuclear regulation agencies | Demand objective cradle to grave assessment re sustainability and risk |  |
| Emerging potential energy sources | E.g. LENR. magnetic, new chemical sources with less impact(s), others? | The new source(s) will come on line by??  Public will accept technology (“nuclear fear”)  Who controls use of these technologies? | Critical review of probable benefit cost or most probable leads to investment  Social impact assessment re impacts | Private industry to lead with???  Public review of use and governance implications | Demand objective cradle to grave assessment re sustainability and risk |  |
| Transmission resulting in efficiencies | Better management of grids | lossless transmission,  smart grids | Technology will provide practical solutions; owners of utilities will use them | Increased investment in research into e.g., nanotech, grid management systems | Private sector, owners of grid system(s) increased public/crown involvement | Lobby utilities and government grid regulators |  |
| Removal of GHG from atmosphere | Sinks | Sequestration- land, oceanic, subterranean | Costs are not prohibitive and absorptive capacity is sufficient and accessible | R and D, field testing, demo projects | Who pays? Governments have will and capacity? | Demand objective cradle to grave assessment re sustainability and risk |  |
| Geo-engineering | Iron into oceans, atmospheric seeding, nanotech means to remove carbon (nanotubules) | Public will accept large scale solutions.  Tests of these work and are clearly safe | R and D, field testing, demo projects, small scale tests | ? (note that past fossil fuel burning was de facto geoengineering | Demand objective cradle to grave assessment re sustainability and risk |  |
|  | Vegetation | Preservation and planting of trees, suitable crops | Stop rainforest depletion and other removal of key buffers (e.g wetlands)  Use of offsets | Public supports use of offsets and investment in protection at home and abroad  Legal basis established to verify offsets | Tourism industry, public, NGOs, any business who can sell offsets | Public demand for companies to provide offset programs and will pay to support them |  |
|  |  | Planting of low fossil energy demand crops | Options exist to reduce use of fossil based fertilizers  Price is acceptable to consumer | Options clearly available, successful demo projects  Option of subsidy for green options or regulation of others | Farming community, Food industry | Public demands these options |  |
|  |  |  |  |  |  |  |  |
| Net GHG neutrality | Offsets/carbon markets | Companies buy and sell permits to pollute (up to limits established by government or market capacity | Governments establish limits and enforce them.  Key companies buy in  Market established on good scientific information re limits and sensitivities | International accords, regional and national standards | Governments, international regulatory bodies | Pay offsets as individual consumer of e.g. travel, energy using products |  |
|  | Closed production systems (0 waste) | Companies find ways to eliminate waste by e.g. reprocessing, zero waste processing methods or systems | Easy approval to use systems.  Eco-industrial parks established (PPP likely means)  Visible demo successes | Integrated planning for industries re location and process  Removal of barriers to co-location and specific processes | Governments, key industries, planning community | Lobby for research into such systems as potential local solutions |  |
| Reducing Consumption | Population reduction | Many, from government limits to effects of e.g women’s education, economic factors | Main social institutions will accept use of birth control, education of women, poor | Education,  Civil society institutions will cooperate  Legal barriers and social constraints eased | Key may be members of churches, civil society, education, NGOs | Lobby, organize, educate.  Stop at two. |  |
| Lower per capita consumption of fossil energy (of all energy) | Carbon Tax  Consumption taxes | Ability to create global or large scale market or shared rules  Public acceptance | Social change, changes in values and definition of “success”  Acceptable lifestyle alternatives found and promoted | Marketplace, social movers and shakers | Peer pressure on most egregious excesses.  Boycott worst polluters |  |
| De-Growth/Stable systems | Changes to main goals of growth oriented system to where growth is not the prime directive | Possible to change perception of values | Education, debate of what we want to sustain, replacing metrics, use of range of indicators re what we want to sustain | Marketplace, social movers and shakers, civil society organizations | Demand that zero or low growth options are considered as alternatives | Conference or debate to educate and focus on stability |
| Choice of lower energy consumptive practices | Lifestyle changes to lower consumption  Alternative means to satisfy wants and experiences developed | Public will choose less energy consumptive options (locavore, eco-travel, no long distance travel, changed food consumption patterns | Education on risks and impacts  Development of satisfying low energy, cost effective alternatives | Marketplace, social movers and shakers | Individual lifestyle choices, peer pressures |  |
| Use of e.g. smart meters and thermostats | turn thermostat down – lifestyle changes acceptable | Education, subsidy, public information, peer pressure, differential pricing put in place and enforced | Utilities and local governments | Participate |  |
| Supply Management | Smoothing of peak uses | Smart metering and time shift of peaks to allow system to depend on renewables | Effective grid and technology to level demand. Time based costing | Education, good programs to reward use of time shift, changing work hours for major users | Utilities  Government re regulatory powers | Personal action to reduce and smooth own use  Demand use of smart metering |  |
| Distributed systems | Self-sufficiency in renewables at house or community scale | Could be off grid, new tech allowed by city bylaws | People understand potentials and risks, costs are reasonable, laws permit off-grid | Utilities, communities, people | Bo it, lobby others to make it easier | Gather and share success stories |
| Distributed generation, smaller scale | Many sites, smaller systems distributed risk as well | Change subsidy systems to favour this means | Utilities, communities | Lobby, invest | Gather and share success stories |
|  | Energy storage | Using sun and wind, even tidal power, to store energy for use at times when energy is in demand with e.g. pumped storage, heated fluids, compressed gasses. | Cost effective options are defined and are scalable to suitable levels (personal, community, regional etc.) | R and D, compilation and sharing of success stories (e.g. Hierro Canaries) | Utilities, tech companies | Lobby jurisdictions and utilities | Gather and share success stories |
| **Adaptation** |  |  |  |  |  |  |  |
| Risk inventory and assessment | Initial communications on climate change, ongoing risk assessments | Main areas of risk identified by governments and programs put in place which respect these | Risk analyses are comprehensive and spatial and identify viable options | Governments respond to e.g. Paris, identify key risk and impact areas and require at regional and local government levels. Establish baseline indicators and monitoring systems at all scales | Local planning and governments | Demand that climate impacts are part of decision process | CACOR does review of successes? |
| Research to define key areas of risk | Governments and insurance industry produce risk maps | Risk levels understood by public, institutions | Publicity of risk areas and potential costs.  Differential taxation and insurance rates and requirements to respect risk | Governments at all levels. | Demand that risks are considered in key decisions with adequate information |  |
| Identification of future probable ecosystems leading to lower risk plans for e.g., land use, species preservation | Risk mapping and modelling showing future likely capacity | IIASA and other eco-models re capacity | Public will understand and accept what is essentially stochastic definitions of future probable ecosystems | Risk analyses can be done effectively and show benefits of changing vulnerable plantings and possible crop losses particularly for perennials | Government, planning authorities | Ask for publicly available results to be easily accessible and ask for discussion of futures and impact on people |  |
| Projections of future demands for products and where to produce them | Economic models re range of demands and locations | Industry will want good spatial advice on where the most productive and sustainable future resources will be as well as needs to serve | Scenarios of demand can be generated and discussed as part of overall demographic and consumption analysis | Government, planning authorities, public fora | Ask for publicly available results to be easily accessible and ask for discussion of futures and impact on ecosystems and people | COR/CACOR capacity to model? |
| Built environment | Pre-emptive planning | Strategic plans | Risk mapping is effective in showing spatial array of risks and options | Investment in risk mapping and research in suitable structures for a range of conditions | Current planning authorities – at all scales | Demand that climate risk is part of analysis and public consultation and reporting systems |  |
| Adaptive planning | Capacity and governance in place to support such planning | Current rigid planning systems can be changed.  Expertise can be obtained sufficient to deal with multivariate factors influencing future scenarios | More courses in universities and industry to accommodate adaptive planning approaches | Current planning authorities – at all scales | Ask your own jurisdiction if it has adaptive planning, other future oriented planning capacity and uses it |  |
| Insurance | Differential pricing to insure based on projected risks | Insurance industry will be interested and will be main player  Modeling of risks can be used to support actuarial analysis | Need to involve both government and industry in scoping and providing suitable information.  Education on full price accounting and why stupidity costs more | Better dialogue on risk among key actors. Share risk information | Public should demand lower premiums for risk reducing behavior – for all |  |
| Incentives to move to safer areas, disincentives to locate in dangerous places | Cooperation between insurance sector and local governments/ planning agencies  Can begin now to move highest risk population now to safer areas | Higher insurance costs will help industry and government to make wiser choices, plus incentives if needed | Planning and zoning authorities, industry sector strategies | Public demands respect for nature and risk. Public asks government to not act as insurer of last resort for stupidity |  |
| Structures | Hardening | Coastal hardening and setbacks, climate suitable structures re storms, heat | Private and public building made suitable to higher risks. (e.g., hotels built on stilts, or further back on beach, docks hardened | Involve public and industries in the planning process.  Information provided on alternatives | Government and private owners/builders, insurers | Ask for rules to deter risky practice and location, demand investment in protective structures |  |
| Protective structures | Strengthened seawalls, refuge structures for severe events | Governments can find resources to retrofit to accommodate risks, build additional structures | Higher insurance costs will help government to make wiser design and investment choices, plus incentives to private sector builds if needed | Generally government but private input can be demanded.  National govt. role in highest risk areas | Ask for clear risk assessment procedures and risk/benefit analyses |  |
|  | Flood channels, holding ponds, urban river floodways | Governments can find resources to retrofit to accommodate risks, build additional structures | Higher insurance costs will help government to make wiser design and investment choices, plus incentives to private sector builds if needed | Generally government:  National govt. role in highest risk areas | Ask for clear risk assessment procedures and risk/benefit analyses |  |
| Distributed energy systems | Diversity and wide distribution of energy systems can make them more robust | New small systems can be efficiently linked | Joint planning and investment by government and industry | Government and industry, incl utilities | Lobby |  |
| Retrofit of current infrastructure to be more resistant to e.g. floods, excessive heat (bending rails) | New builds and projects to reinforce areas of greatest vulnerability e.g bridges, hospitals | Risks can be sufficiently estimated and response targeted to key infrastructural risk. Standards need to be revised to accommodate changed conditions | Higher insurance costs will help industry and government to make wiser choices, plus incentives if needed | Government – mainly regulators | Demand evaluation of current infrastructure re new conditions |  |
| Transportation | Relocation of key infrastructure and retrofit (e.g. roads and rails in flood channels, coasts. | Plan new infra-structure for safer places, require retrofit for most vulnerable | Timing re renewals and retrofit can make it affordable.  Risks are understood and built into solutions | Higher insurance costs will help industry and government to make wiser choices, plus incentives if needed | Government and utilities | Demand evaluation of current infrastructure re new conditions, action to fix |  |
| Design to be robust under wider range of temperatures (e.g, changed materials, longer runways, runoff resistant roads | Build risk analysis and CC impact studies into design process.  Move, change or reinforce now | CC risk analysis becomes inherent component of planning and design.  Costs of not building  CC risks into builds is recognized | Lenders and insurers will participate in making risk assessment part of their choices – and make the results known to potential clients. | Investors, builders, banks, insurers | Ask for clear risk assessment procedures and risk/benefit analyses |  |
| Agriculture | Robust crops | Hybrids, GM to be less sensitive to heat, drought etc.  Less meat | People will buy these, change food preferences or sources if required | Education re safety and need  Demo projects show the way | Food industry, agricultural research, consumers | Adapt your own diet, be flexible re changed crops, such as GMO |  |
|  | Land reserves | Plan and protect those areas most resilient under widest range of likely futures | Public will accept that some areas are essential for e.g. food security or habitat and should be saved for these – e.g land reserves for best soils, future productive areas | Governments accept long term planning horizons which encompass sustainability goals | Government agencies | Accept that some areas are more valuable for strategic purposes for food security and support their protection |  |
|  | Future-based planting of perennials and future risk based land use choices | See trees below, creation of land reserves | Public will accept that some areas are essential for e.g. food security or habitat and should be saved and used for these | Governments accept long term planning horizons which encompass sustainability goals. Finance available for long term strategic planting of robust species, Reserves set aside for future | Planners, agricultural and rural finance bodies | Ask that future be part of discussion for food production |  |
| Forestry | Match plantings to likely future ecosystems | Plant trees at places where they can mature given likely future range suitable | Forest industry will understand need for futures based risk reduction in their planting | Models are used to estimate future ecosystems when reforestation done | Forestry firms and forestry departments | Ask for biodiverse future based tree planting. |  |
| Lifestyle adaptation | Lower own footprint | Live off grid, self- sufficiency, low energy choices, eschew consumption | Public will choose less energy consumptive options (locavore, eco-travel, no long distance travel, green builds) | Demo projects, information sharing on individual success stories | Everyone  Civil society, NGOs, government s | Be actively part of the solution re your own lifestyle and investments |  |
| Emergency planning | Capacity to respond to more extreme weather events, floods, droughts, contingency planning. Recovery strategies | Emergency plans, escape paths, refuge centres, communication capacity, emergency training  Identify safe places for temp/perm resettlement | Jurisdictions will put plans in place, share risk response at larger scales, support recovery work | International bank of best practice accessible to all nations, jurisdictions | All scales from individual to international - | Demand that each level of government has emergency plan for future risk (respecting climate change as a key factor) |  |
| Emergency response | Capacity and supplies in place to meet wide range of emergency situations | Pre-position staff and supplies  Identify emergency transport capacity | Emergency plans and capacity can be done at appropriate scale and that jurisdictions will work together where needed | Set up interjurisdictional planning now  Fund it. | Local to international | Have your own emergency plan for e.g flood, fire.  Demand that your community has one |  |
|  | Interregional and international communications capacity in place to support timely response | Contingency planning and pre-organized networks, rosters of expertise, emergency staff | Climate change will be seen as a real risk and money spent to see that links are in place. | Set up capacity now and involve all key actors | All levels of government, military and civilian | Demand that key infrastructure is in place |  |
| Migration response | Improved capacity to manage refugees and famine victims | Range including worst case scenarios modelled. Pre identification of e.g. routes, transport, housing, care options, resettlement | Interregional and international cooperation | UN lead is accepted along with key regional organizations and NGOs | Nations, cities, NGOs, civil society | Demand a risk management and emergency management contingency plan is put in place. |  |

*Note that once the final column is addressed (to be done as a dialogue with members) we can add two columns to the right – one on the significance of the effort and a second one on the probability of making a difference to help scope the most likely effective activities. The items in red are a first run at a menu of areas which CACOR could begin to address; it is just a start.*

**Logistics**

The above table is designed to focus attention and debate on what is to be done and also what is likely to be most effective in terms of results for level of effort applied. It shows the full range of actions which together may address the issue. As is obvious, many actors will have to buy in but every action can be a building block towards a sustainable solution.

Of course, actions need to be SMARTT:

1. Specific,
2. Measureable,
3. Achievable (things that are technically feasible),
4. Realistic (sufficient to bring about the desired result),
5. Timely (things must be done with whatever dispatch is needed to ensure the undesired result(s) do not happen), and
6. Time-bound, (within a specific timeframe for accomplishment)

Further, the logical choice of what to do will necessarily respect the following logical components:

* actions which ideally address the biggest sources of GHGs
* actions which address the GHG sources that are most easily changed via technology adjustment or replacement
* actions are with the organizations capabilities and responsibilities
* actions won't or are unlikely to have undesired effects of their own for which compensation is not planned
* Actions which can be scoped as realistically able to be accomplished given the resources and capabilities of the organization and it allies

Therefore, a simple form of applied benefit/cost analysis could be notionally applied to probable candidates. To assist in clarity in analysis of what is likely to make a difference it will be useful to use a set of indicators as metrics for what is precisely intended and to measure progress relative to any achievement for candidate projects or activities..

*Draft Prepared for CACOR by Ted Manning with input from David Dougherty and Ian Whyte. Mar 2016*