مؤسسة رفيق الحريري

وقائع مؤتمر

الـتـرابـط

بين

المياه والغذاء والطاقة

المياه والغذاء والطاقة

هاتف 01-853055
فاكس 01-853006

البريد الإلكتروني:
rhf@rafichariri-foundation.org

الموقع الإلكتروني:
www.rhf.org.lb

الطبعة الأولى 2014

ISBN 978-9953-0-3023-4

صدر في لبنان
مركز الطباعة الحديثة ـ بيروت

الترابط
بين
المياه والغذاء والطاقة

25 تشرين الأول 2013

بيت الأمم المتحدة (الاسكوا)

بيروت - لبنان

الفهــرس

Table of Contents

جلســة الافتتــاح
Opening Session

السيدة سلوى السنيورة بعاصيري

المديرة العامة

مؤسسة رفيق الحريري

إنه لمن دواعي اعتزازي أن أرحب بكم باسم مؤسسة رفيق الحريري، وأن أنقل إليكم تحيات رئيستها السيدة نازك رفيق الحريري التي أسعدها كثيراً أن تكون المؤسسة قد تعاونت ولجنة الأمم المتحدة الاقتصادية والاجتماعية لغربي آسيا (الاسكوا) في تنظيم مؤتمر اليوم، لما يعنيه هذا التعاون من ترجمة لعمق الروابط التي جمعت وتجمع بينهما على اكثر من صعيد، تستذكر منها السيدة نازك ونستذكر معها الاتي:

أولاً: الجهود الكبرى التي بذلها دولة الرئيس رفيق الحريري في حينه، والتسهيلات المتعددة الجانب التي وفرها، لكي يعود لبنان مقراً للاسكوا في العام 1997، بعد غياب الاسكوا القسري عن لبنان لمدة خمسة عشر عاماً؛

ثانياً: مبادرة الاسكوا إلى ترشيح الرئيس رفيق الحريري لجائزة الأمم المتحدة للمستوطنات البشرية للعام 2004، والتي نالها تقديراً لإبداعاته وريادته ومكانته كرجل دولة، أعاد إعمار لبنان والعاصمة بيروت؛

ثالثاً: القضايا المشتركة التي تتقاطع في إطارها جهود الاسكوا ومؤسسة رفيق الحريري والتي تصب جميعها في السعي للرفع من مكانة الانسان وشأنه في مجتمعه والمحيط؛

وها هو مؤتمر اليوم، الذي أرادته مؤسسة رفيق الحريري أن ينعقد بالتزامن مع احتفالات يوم الأمم المتحدة، ومع اطلاق مسح موارد المياه المشتركة في غربي آسيا نظراً لرمزية المناسبة، هو مخصص في المقدمة للتداول بمسائل محورية تشغل مفكرينا والباحثين، وتحتل مضامينه موقعاً متقدماً في أولويات الاسكوا واهتماماتها، لما يترتب عن تلك المضامين من تداعيات تطال اقتصادات الدول العربية الأعضاء وحال الاستقرار الاجتماعي فيها.

قد يجدر التنويه أن اختيار مؤسسة رفيق الحريري لموضوع مؤتمر اليوم إنما يصب في السياق العام لإطلاقها سلسلة مؤتمرات ستتناول جميعها قضايا حية تشغل المجتمع اللبناني، ومسائل إنسانية محورية بحاجة للتفكر والتأمل، إن لم يكن للتوصل لإجابات شافية بشأنها، فلعله للسعي لتقديم رؤى وتصورات لسبل التعامل معها. وسوف تتحلق لمقاربة تلك القضايا والمسائل كواكب مشعة تضيئ الشعلة التي ائتمن رفيق الحريري المؤسسة على حملها منذ العام 1984. وكم كان على يقين حينها أن الشعلة ستضاء بآلاف من الأنوار. أنوار الطاقات اللبنانية الشابة الممثلة لجميع مكونات المجتمع اللبناني والتي دفعها طموحها إلى التقاط فرص الالتحاق بأرقى الجامعات، في لبنان وفي شتى بقاع العالم، لتكون مهيّئة للإسهام في إعادة إعمار لبنان، الذي كان ولا يزال في أمس الحاجة إلى طاقات أبنائه ليستعيد عافيته وازدهاره، ويحصن سيادته، ويعزز وطنيّته، ويؤمن استقراره.

إن الحاجة لانتظام حياة مستقرة ومزدهرة، تُحفظ فيها كرامة الإنسان وأمنه، ليست حكراً على لبنان، بل هي حاجة ملحة في اكثر من بلد عربي، بعد أن تشعبت وتداخلت الأسباب الكامنة وراء هشاشة الأوضاع وعدم الاستقرار في معظمها، وإن بقي العامل المركب، الاقتصادي الاجتماعي البيئي، في مقدمة العوامل التي أثّرت سلباً في مسار الأمور، لكونه العامل الأهم في دفع قاطرة التنمية، ولكون في تعثره تتعثر التنمية بشتى أبعادها. وها هو التقرير العربي، الصادر مؤخرا حول الأهداف الإنمائية للألفية الثالثة، يؤكد ذلك التعثر في إشارته إلى أن 20٪ من العرب يهددهم الجوع، بعد أن كانت نسبتهم بحدود 15٪ في العام 2011.

إزاء هذا التردي المتسارع في واقع الأمن الغذائي في العالم العربي، والأمر عينه على مستوى العالم ككل حيث يقدر أن هناك راهناً ما يفوق المليار ونصف المليار نسمة يعيشون في فقر متعدد البعد، يرى الباحثون إزاء ذلك أن ازدياد الجوع لا ينفصل عن ازدياد العطش. فشح مخزون المياه

الصالحة للشرب وتلك المتاحة للزراعة إضافة إلى تقلص المساحات الصالحة للزراعة، يجعل من الجوع والعطش مجتمعين سبباً إضافياً لتعميق الانحدار نحو الأسوأ. إلا أنهما بدورهما، أي الجوع والعطش، لا ينفصلان عن تركيبة مجمل عواقب تغير المناخ، وتحديداً الجفاف والتصحر والسيول والفيضانات، في حين أنّ تغير المناخ لا ينفصل هو أيضاً عن تداعيات طرق الاستخدامات غير الصديقة للبيئة في إطار الاعتماد المتمادي على الطاقة التقليدية، والتي تُسأل عن تلوث الغلاف الجوي ومياه الأنهار والمياه الجوفية، نتيجة النشاطات البشرية الملوثة للبيئة.

إذن هي حلقات مترابطة يؤثر بعضها في البعض الاخر، فهل يمكن استطراداً الأخذ بأنه في حال إستخدمت مصادر طاقة بديلة يمكن للبيئة أن تتلوث أقل؟ وهل في حال تردي بيئي أقل، هل تُحمى المياه من عواقب التلوث والندرة؟ وهل في حال سلامة المياه سنضمن الامن الغذائي؟

إذا كانت الاجابات بنعم كيف نؤكد صحة تلازم التأثيرات المتبادلة وكيف نقيس أحجامها؟

أدرك جيداً أن ليس في ما سبق ذكره من جديد، فلطالما جرى الحديث عن محورية قطاعات المياه والغذاء والطاقة باعتبارها، منفردة ومجتمعة ومتداخلة، تشكل المحرّك لعجلة الحياة، وتستجيب للتوسع المتنامي لحاجات الإنسان التي ترتفع وتيرتها باستمرار، وذلك بغية تحقق التنمية المستدامة. ولكن المستجد هو الحديث مؤخراً عن ضرورة البحث في طبيعة الترابط بين أضلاع المثلث الذهبي الماء والغذاء والطاقة، ودراسة تأثيراته المتبادلة، كماً ونوعاً، وضرورة تسخير الابتكار والتقدم العلمي والتكنولوجي والبحثي لدراسة طبيعة الترابط المتعدد الأوجه ذاك، بالاعتماد على مقاربات دامجة غير مجتزءة أو أحادية الجانب، كما ضرورة صياغة استراتيجيات متكاملة، لمجتمعات أكثر تكيفاً ومناعة، تخدم جميعها في تحقيق غايات التنمية المستدامة، سيما وأننا مدعوون أن نشهد وجهاً آخر للعالم في العام 2020، بعد أن أعلنت معظم الدول عن رؤى تطويرية لكل منها تأمل إنجازها بحلول العام 2020، وترتكز في جوهرها على إيجاد توازن أكبر في التعامل مع الموارد الطبيعية. ونحن مدعوون أيضاً لنرى عالماً أكثر إنصافاً في العام 2030، بعد أن حدد البنك الدولي العام 2030 تاريخاً جديداً للقضاء على الفقر المدقع.

لقد اختار مؤتمرنا اليوم أن يخوض غمار البحث في ذاك الجديد، فعساه ينجح في مقاربة أبعاد الترابط من جميع جوانبه، ويوفق في رسم ملامح مبادرات يتم الانطلاق منها لصوغ سياسات ووضع خطط استراتيجية، وطنية وإقليمية، تصب في توظيف الترابط بين الماء والغذاء و الطاقة في خدمة أهداف التنمية المستدامة، واننا على يقين أن مشاركة مرجعيات مرموقة وكفاءات عالية في فعاليات المؤتمر هي ضمانة لتحقيق الغاية والهدف. فالشكر لهم فرداً فرداً باسم مؤسسة رفيق الحريري، وبالنيابة عن رئيستها السيدة نازك رفيق الحريري، تقديراً لجهودهم الحثيثة ومساهماتهم القيمة.

والشكر ممتد للأمينة التنفيذية للاسكوا الدكتورة ريما خلف ونائب الأمينة التنفيذية الدكتور نديم خوري ومديرة إدارة التنمية المستدامة والإنتاجية الدكتورة رولا مجدلاني على جميل تعاونهم في سبيل إنجاح مؤتمر اليوم.

وكم يسعدني في الختام أن أتوجه بالشكر إلى الدكتور دومينيك وافري الذي تكرّم بقبول دعوتنا إلى فعاليات مؤتمر اليوم ليشارك المنتدين والحضور الكريم خبراته المميّزة في موضوع المؤتمر، وهي خبرات نجده يستثمرها في اطار المنتدى الاقتصادي العالمي وفي محافل عديدة أخرى، وهي حكماً ستثري مؤتمرنا ومخرجاته.

Ms. Salwa Siniora Baasiri
Director General,
Rafik Hariri Foundation

It is a great privilege to welcome you on behalf of Rafik Hariri Foundation (RHF), and to convey to you the greetings of the president of the Foundation Mrs. Nazek Rafik Hariri, who has been very pleased to see the Foundation cooperate with the United Nations Economic and Social Commission for Western Asia (ESCWA) in organizing this conference. This cooperation reflects the strong ties that bond ESCWA and RHF in various domains, among which, Mrs. Hariri and we recall the following:

- The major efforts that Prime Minister Rafik Hariri rendered and the facilities he provided, in order to have the ESCWA headquarters be back to Lebanon in 1997, after a forced absence for fifteen years;

- ESCWA initiative in 2004 to nominate Rafik Hariri for the award of the United Nations Human Settlements Programme, UN Habitat, which he received in recognition of his innovative initiatives, his leadership and statesmanship; He who led the reconstruction of Lebanon and the capital Beirut;

- ESCWA and RHF cross cutting efforts and preoccupations which focus on raising the overall standing of the human being and enhancing his role within his society and beyond;

Further still, the conference of today, which the RHF opted to have it coincide with the UN Day and the launching of the Inventory of Shared Water Resources in Western Asia, is dedicated to address a pivotal issue which, while engaging policy makers and researchers, is considered among ESCWA priorities and concerns, taking into account its multifaceted impacts on the economies and the well being of the societies of the ESCWA member countries.

It is worth mentioning, however, that the conference theme, as chosen by RHF, falls within the context of a series of prospective conferences which the RHF plans to organize in order to address key and vital humanitarian issues that need to be looked into, being of great concern to the Lebanese society. The main objective for holding such conferences is to seek the insights and perceptions of the group of distinguished intellectuals and scholars who have given a special glamour to the flame that Rafik Hariri entrusted the RHF with, since its inception in 1984. Rafik Hariri was certain then that the flame will be lit by thousands of young Lebanese students who represent the mosaic texture of the Lebanese society, and whose great ambitions and expectations have carried them to the best universities, in Lebanon and around the world, to be empowered and well prepared to contribute to the reconstruction of Lebanon, the Lebanon that needed and still needs the energies of its citizens to reclaim its prosperity, to fortify its sovereignty, to promote patriotism and to provide sustainable stability.

In fact, the need for a stable and prosperous life that ensures human dignity and security is not of concern to Lebanon only, it is of concern as well to most countries of the Arab region, being vulnerable in more than one area, mainly the socio-economic and environmental realm, which stands out as the most pertinent in negatively affecting the developmental path. This negative trend has been strongly confirmed by the recently issued Arab report on the Millennium Development Goals, which records that 20% of the Arab population are threatened by hunger, compared to a 15% in 2011.

This rapid declining trend in food security in the Arab region appears to be congruent with the global trend, where there are currently more than one billion and a half people living in poverty. Accordingly, the researchers argue that the increase in hunger is inseparable from the accelerating decrease in fresh water reserves for drinking water and for agriculture, in addition to the decrease in arable areas. They also argue that the twinning of thirst and hunger will certainly deepen the regression for the worse, being aware that thirst and hunger are also affected, separately and jointly, by the overall consequences of climate change, in particular drought, desertification and floods. In turn, climate change is found to be inseparable from the repercussions of the extensive usage of the fossil energy, which is responsible for the atmospheric pollution, as well as the pollutions of rivers and groundwater, all being the results of human pollutant activities.

Accordingly, an interwoven synergy is being observed among the sectors of water, food and energy. A fact which makes us wonder whether the use of renewable energy sources would less pollute the environment! And in the event of less environmental degradation, would that protect the water from pollution and scarcity? Also in the event of water abundance will that ensure food security? If the answers are yes, how to measure and quantify the mutual influences?

I am aware that the afore-mentioned reasoning with regards to water, food and energy inter-linkage is not a new topic. The recurrent analysis of this inter-linkage has always been targeting to realize sustainable development.

However, the emerging concern stems mainly from the need to explore the quantitative and qualitative natures of interdependence between water, food and energy. Also the need to dedicate innovation, scientific and technological progress, as well as research, towards studying the nature of the nexus. Moreover, there is a need to develop integrated strategies, related to the nexus, that would serve in achieving the sustainable development goals, knowing that we are invited to witness, by year 2020, new profiles for several countries which have committed themselves to achieve sustainable development goals by that date. We are also invited to see a more equitable world in the year 2030, considering that the World Bank has identified the year 2030 a new date for the elimination of extreme poverty.

Accordingly, the present conference has opted to venture into a new domain, that of exploring the nature of the nexus, as well as its various multidimensional implications, with the objective of deepening and enhancing the know how about the various aspects of the nexus, also to help in formulating policies and developing strategic plans, national and regional, that could align the water food energy nexus into the service of the sustainable development goals.

We are sure that our distinguished and highly qualified experts would help, via their participation in this conference, in achieving the set objectives. So, I would like, in the name of the Rafik Hariri Foundation and on behalf of its President Mrs. Nazek Rafik Hariri, to thank them one by one for their relentless efforts and valuable contributions. Thanks also go to ESCWA, represented by the Under-Secretary General, the Executive Secretary Dr. Rima Khalaf, the Deputy Executive Secretary Dr. Nadim Khoury, and Ms. Rola Majdalani, Director, Sustainable Development and Productivity Division, for their precious cooperation and fruitful collaboration.

Before I conclude, may I extend special thanks to Dr. Dominic Waughray, who has been generous enough to welcome our invitation to partake in the conference of today, in order to share, with the participants and the audience, his distinguished expertise on the Nexus. An expertise that he has invested at the World Economic Forum and elsewhere, and it will sure enrich our conference and its outcomes.

الدكتور نديم خوري

نائب الأمين التنفيذي
اللجنة الاقتصادية والاجتماعية لغربي آسيا (اسكوا)

يسعدني أن أشارككم اليوم في افتتاح هذا المؤتمر الهام حول الترابط بين المياه والغذاء والطاقة، لما لهذا الترابط من تأثير إيجابي على التنمية الاجتماعية والاقتصادية والبيئية المستدامة. وهنا اسمحوا لي أن ارحب بكم في بيت الأمم المتحدة وفي ذات الوقت التأكيد على سعادتي لمشاركة الاسكوا في تنظيم هذا الاجتماع مع مؤسسة رفيق الحريري، وهنا لا تفوتني فرصة التعبير عن عظيم التقدير للرئيس الشهيد رفيق الحريري ورؤيته التنموية وخاصة في مجال دعم الشباب اللبناني في مجال التعليم العالي والذي نتج عنه سته وثلاثون ألف خريج جامعي ، فهذا الاستثمار في الإنسان العربي باعتباره محور ومحرك التنمية هو من أهم أوجه التنمية المستدامة.

يهدف هذا المؤتمر إلى إفساح المجال للحوار حول الترابط بين قطاعات أساسية من الموارد الطبيعية، بين المياه والغذاء والطاقة، بحثاً عن سبل ناجعة لمواجهة التحديات الضخمة في هذا المجال ووضع خطط استراتيجية لإدارة مستدامة لهذه الموارد.

الزملاء الكرام،

كما تعلمون، إنّ الجزء الأكبر من إجمالي مساحة البلدان العربية يقع في بيئات جافة وشبه جافة بل وقاحلة في بعض المناطق، مما يجعل ندرة الموارد المائية ميزة ملازمة للمنطقة العربية. لقد انعكس عدم توفر المياه وتزايد شحتها على قطاع الزراعة وبالتالي على الأمن الغذائي في المنطقة، إذ أن إجمالي المساحات المزروعة الحالية لا تشكل إلا ما نسبته 5,3 ٪ فقط من إجمالي المساحة الجغرافية

للوطن العربي. أما بالنسبة لموارد الطاقة ، فبالرغم من توفرها بشكل ملحوظ في بعض بلدان المنطقة العربية، إلا أنها لا تزال تمثل عبئاً مالياً واقتصادياً كبيراً على اقتصاديات بعض الدول الأخرى. إن هذا التباين الواضح في توزيع الموارد الطبيعية من مياه وأراضي زراعية ومصادر الطاقة في المنطقة العربية قد أثر على التنمية الاقتصادية والاجتماعية وأدى إلى تنامي ظاهرة الهجرة خصوصا من الريف إلى المدينة داخل الوطن الواحد، وكذلك إلى خارج حدود الوطن بحثا عن سبل العيش الكريم. لقد اصبح لزاما علينا العمل على تعزيز المعرفة الكفيلة بتوضيح كيفية مقاربة القضايا الملحة للترابط بين المياه والغذاء والطاقة.

إن آفاق التكامل بين استخدام موارد المياه والزراعة والطاقة على الصعيد الوطني واسعة، وبدراستها بمنهجية علمية، يمكن أن تؤدي إلى تحديد الممارسات والآليات ذات التأثير الإيجابي الأفضل على التنمية الاقتصادية والاجتماعية. في هذا السياق، لا بد للبنان و لبلدان المنطقة العربية من رسم سياسات وتبني ممارسات تنموية كفيلة بتحقيق التخطيط والإدارة المتكاملة والشاملة في مجالات الطاقة، والمياه، والأمن الغذائي للأجيال الحالية والمستقبلية. ولذلك يمكن لنهج تشاوري يضم الحكومات، والجامعات، وأصحاب المصلحة في القطاع العام دعم تحقيق هذا الهدف.

أما على الصعيد العالمي، فقد تم رسم الأطر العامة للتوجهات المستقبلية الدولية في ما يتعلق بالتنمية المستدامة من خلال الوثيقة الصادرة عن مؤتمر الأمم المتحدة للتنمية المستدامة «ريو +20» تحت عنوان «المستقبل الذي نصبو إليه» أو«The future we want». وإدراكاً منا لخصوصية المنطقة العربية وضرورة اخذ هذه الخصوصية في الاعتبار عند صياغة برامج التنمية العالمية؛ تقوم الاسكوا، بالتعاون مع جامعة الدول العربية والمنظمات الدولية والإقليمية العاملة في مجال التنمية، بالدفع باتجاه أن تتضمّن أهداف التنمية المستدامة الجاري إعدادها أهدافاً واضحة يمكن قياسها، وتستند إلى مخرجات البحث العلمي ، وتسمح بإمكانية تقييم التقدّم المحرز في التنمية، وان تراعي الأهداف المستقبلية للتنمية المستدامة قطاعات الغذاء، والطاقة، والمياه.

وتجدر الإشارة أنه قد تم تعيين 2013 السنة الدولية للتعاون في مجال المياه. وفي هذا الإطار بات لا بد من تكثيف الجهود والتعاون بين مختلف أصحاب المصلحة والمعنيين لتطوير تقنيات الري ورفع كفاءته ونظم تحلية المياه، ومعالجة مياه الصرف الصحي وإعادة استخدامها. أما في مجال الطاقة، فيجب إعطاء اهتمام خاص لرفع كفاءة إنتاج واستهلاك الطاقة والتوجه الجاد نحو مصادر الطاقة البديلة والمستدامة.

السيدات والسادة،

وحرصا منا على أهمية العلاقة الترابطية بين المياه والطاقة، فقد نظمت الاسكوا اجتماعاً حكومياً تشاورياً في بيروت في حزيران من العام الماضي، ضم أعضاء لجنة الموارد المائية وأعضاء لجنة الطاقة لدول الاسكوا ، حيث تمحور الاجتماع حول موضوع «الترابط بين قطاعي المياه والطاقة في بلدان الاسكوا» بهدف تحديد الأولويات التي تستوجب دراسة واهتماماً أكبر من قبل البلدان، وقد برزت قضايا التوعية وزيادة معرفة الخيارات التقنية بالإضافة إلى رفع الكفاءة والترويج للطاقة المتجددة كقضايا ذات أولوية على المدى القصير والمتوسط.

وللتأكيد على اهتمام الأمم المتحدة بموضوع الترابط بين المياه والطاقة في البلدان العربية، تمت الموافقة على برنامج «تطوير قدرات البلدان الأعضاء في الاسكوا لمعالجة الترابط بين المياه والطاقة لتحقيق أهداف التنمية المستدامة» الذي سيبدأ أنشطته في عام 2015 والممول من مخصصات حساب التنمية للأمم المتحدة، وسيتضمن هذا البرنامج إعداد الآليات والترتيبات المؤسساتية الممكنة لتنظيم التنسيق والمواءمة في السياسات المعتمدة في مجالي الطاقة والمياه وكذلك عقد ورش عمل إقليمية تدريبية حول تلك الآليات والترتيبات والتعريف بالخيارات التقنية في هذه المجالات. كما ستقوم الاسكوا بإصدار تقرير يتناول موضوع آفاق الترابط بين المياه، والغذاء والطاقة في المنطقة العربية خلال العام 2015.

وبهذه المناسبة اسمحوا لي بان أطلب منكم، انتم عينة من نتاج استثمار الرئيس الشهيد رفيق الحريري في الإنسان العربي، خصوصا أساتذة الجامعات منكم، اقتراح مواضيع بحثية للدراسات العليا في مجالات الترابط بين المياه، والغذاء والطاقة لرفع مستوى المعرفة العلمية العربية في هذا المجال.

الحضور الكريم،

في الختام أشكر حضوركم ومشاركتكم في هذا المؤتمر، وأنتهز الفرصة لأجدد التزام الاسكوا التعاون مع الحكومات ومراكز الأبحاث في الجامعات و أصحاب المصلحة في القطاع العام و القطاع الخاص لدعم الجهود الوطنية والإقليمية لتعميق المعرفة بالعلاقة الترابطية بين المياه والغذاء والطاقة لما يلبي متطلبات التنمية الاجتماعية والاقتصادية والبيئية المستدامة في منطقتنا العربية.

Nadim Khouri, PhD
Deputy Executive Secretary
ESCWA

I am pleased to join you today at the opening of this important conference about the water, food and energy nexus and its potential importance in exerting a positive impact on socio-economic development and environmental sustainability. Let me welcome you at the UN House and at the same time express my pleasure to collaboration with the Rafik Hariri Foundation in organizing this meeting. I would also like to take this opportunity to express my great appreciation to President Rafik Hariri and his vision of development including his support for the Lebanese youth in the field of higher education, which resulted in about thirty six thousand university graduates from his contributions. This investment in the Arab individual as the center and the engine of development is one of the most important aspects of sustainable development.

Knowing the strong interlink-ages between the key natural resources, this conference is meant to serve as a platform to discuss the interlink-ages across the water, food and energy sectors with a view to finding effective ways to tackle the related daunting challenges and develop strategic plans for the sustainable management of these resources.

Distinguished Colleagues,

As you well know, the major part of the total surface area of Arab countries is located in arid and semi-arid environments and even barren in some areas, making water scarcity an inherent characteristic of the Arab region. This increasing scarcity has impacted the agricultural sector and consequently food security in the region, as the current total cultivated area in the region constitutes only 5.3 % of the total geographical area of the Arab region. As for energy resources, despite its significant availability in some Arab countries, it still remains a financial and economic burden on the economies of some other countries of the region. This apparent disparity in the distribution of natural resources, such as water, agricultural land and energy resources in the Arab region, has impacted the socio-economic development and has led to the growing phenomenon of migration, especially from rural areas to the city internally and also outside the borders of countries, in search of a decent livelihood. It has become imperative for us to work on enhancing the knowledge to ensure and clarify means on how to approach the pressing issues of the interrelationships between water, food and energy.

The prospects of integrating the use of water, agriculture and energy resources at the national level are wide, and can be studied through a scientific methodology that could lead to the identification of best practices with positive impact on the economic and social development. In this context, it is imperative, for Lebanon and the countries of the Arab region, to formulate multi-sectoral policies and adopt development practices capable of achieving integrated and comprehensive planning and management in the areas of energy, water, and food security for current and future generations. A consultative approach that involves Governments, universities, and public sector stakeholders can support the achievement of this goal.

On the global level, general frameworks for future trends with respect to international sustainable development have been drawn through the statement "The Future We Want" released as an outcome of the United Nations Conference on Sustainable Development Rio+20. Aware of the particular characteristics of the Arab region and the need to take these characteristics into consideration when formulating development programs, ESCWA , in cooperation with the League of Arab States and international and regional organizations working in the field of development, is pushing forward the need to include clear and measurable sustainable development goals and objectives, based on the outputs of scientific research, and allowing the possibility of assessing the progress made in this context. The need to take into account the food, energy, and water sectors in the future sustainable development goals are also continuously emphasized.

As the year 2013 was designated the International Year for Water Cooperation it is yet further necessary to intensify efforts and cooperation among the various stakeholders in order to develop appropriate technologies to raise the efficiency of irrigation systems and water desalination techniques, as well as wastewater treatment and reuse. In the field of energy, special attention should be given to raising the efficiency of energy production and consumption and promote directing our efforts towards alternative and sustainable sources of energy.

Ladies and Gentlemen,

Given the importance of the correlation between water and energy, ESCWA has organized an intergovernmental consultation meeting in Beirut in June of last year that included members of the ESCWA Committee on Water Resources and the ESCWA Committee on Energy. The meeting was focused on “interdependencies between the water and energy sectors in ESCWA member countries” and its aim was to identify priorities that require further study and attention by countries. Several issues have emerged out of the discussions, such as awareness and the increase of knowledge in the technical options, in addition to the need to raise the efficiency and promote of renewable energy as priority issues in the short and medium term.

In order to emphasize the importance of the water, food and energy nexus in Arab countries, a programme to “Develop the capacities of ESCWA member countries to address the linkages between water and energy to achieve the objectives of sustainable development" was approved and will start its activities in 2015, funded by the Development Account of the United Nations. This programme will set up mechanisms and possible institutional arrangements to organize the coordination and harmonization of policies adopted in the areas of energy and water, as well as holding regional workshops on these training mechanisms and the technical options in these areas. ESCWA will also issue a development report on the theme of the water, food and energy nexus and it prospects in the Arab in 2015.

On this occasion, allow me to ask you, as you represent the product of the investment of Prime Minister Rafik Hariri in the Arab human, in particular university professors, to suggest research topics for postgraduate studies in the areas of linkages between water, food and energy in order to raise the level of Arabic scientific knowledge in this area.

Distinguished guests,

In conclusion, I would like to thank you for your attendance and participation in this conference, and take the opportunity to renew the commitment of ESCWA in cooperating with Governments, university research centers, as well as public and private sector stakeholders, to support national and regional efforts to deepen the knowledge of the relationship between water, food and energy and to meet the requirements of socio-economic and environmental development in the Arab region.

Dominic Waughray, PhD
Senior Director and Head of Environmental Initiatives
World Economic Forum

The Need for Fresh Water Economics

The future security of freshwater resources around the world is of increasing concern. Due to our interlinked global economy, water scarcity in many parts of the world could harm the global economy in ways we hadn't thought of. Shortfalls in crop yields and more variable food prices could be an early impact.

This is because our demand for water is closely linked to our overall economic growth. As we grow wealthier, the more cities, power plants, factories and high protein food (dairy, meat, fish, etc.) we demand, the more freshwater we require.

It is not simply a question of more people requiring more water. Rather, it is a case of more wealthy societies demanding much more

---

This informal discussion paper has been produced by the World Economic Forum Water Initiative for the Bonn Conference. The paper does not necessarily reflect the institutional position of the World Economic Forum, its members or any other stakeholders involved in the World Economic Forum Water Initiative. All statistics used in this paper can be found fully referenced in "Water Security: the Water-Food-Energy-Climate Nexus," a book by the World Economic Forum Water Initiative, published by Island Press, 2011. ISBN 13:978-1- 59726-735-9. Copyright © 2011 World Economic Forum. The World Economic Forum gratefully acknowledges McKinsey & Company as its official Project Adviser for the Forum Water Initiative water. During the 20th century, for example, while population grew by factor four, freshwater withdrawals grew by factor nine, primarily as our economies grew.

We should celebrate the fact that the world economy is lifting more people out of severe poverty than ever before. However, if we take these past patterns of economic growth and water use and look forward, the outlook to 2030 is worrying.

Currently about 70% of the world's freshwater withdrawals are for agriculture, 16% are for energy and industry and 14% are for domestic purposes.

Recent work by the Water Resources Group suggests that unless we change our historic approach to how we use water, we could face a 40% gap by 2030 between our global demand for freshwater and what can sustainably be supplied.

Why is this? And what are the implications?

One key area is food. To meet forecast growth in demand for food over the next 20 years, farmers will need to increase global agricultural production by 70-100%. More than 25% of this increase in grain demand will actually be due to changes in consumer diets (more grain for more livestock for more meat), rather than simply to population growth alone. This is because wealthier, more urban diets mean an increase in demand for meat and dairy products in particular. And as we grow wealthier, we grow thirstier. Up to 20,000 liters of water are required to produce a kilogram of meat (compared to about 1,200 liters of water to produce a kilo of grain). Global demand for meat is forecast to increase 50% by 2025, driven especially by increasing income and changing consumer choices in fast growing Asian economies. In China, for example, consumption of meat has increased from fewer than 20 grams per capita per day to 150 grams. This is, however, still far behind the 350 to 400 grams consumed per capita per day in the United States. Herein lies the water challenge. If we already use over 70% of freshwater withdrawals for agriculture and we face an increase in demand for food by 70% by 2030, especially in water-intensive meat and dairy production, it is clear that a business-as-usual approach for managing our agricultural water use is not an option. We can't use over 100% of our freshwater for agriculture. Significant - perhaps radical - changes in agricultural water usage and how we use water in our food production supply chain will be required.

At the same time as we face an agricultural-water challenge, our demand for energy will also grow. Energy is also a thirsty sector.

The International Energy Agency forecasts that the world economy will demand at least 40% more energy by 2030 compared to today. McKinsey and Company estimate 77% of the power stations we will need by then have yet to be built. By that year, China will need to expand its power generating capacity by over 1,300 GW (1.5 times the current level of the United States); and India by 400 GW (equal to the current combined total power generation of Japan, South Korea and Australia).

Increasing access to energy is a priority for many countries -1.5 billion people in the developing world still lack access to electricity and over 3 billion people rely on biomass for heating and cooking. To draw attention to this important issue, 2012 is the United Nations Year of Energy Access. Yet, the energy value chain needs a lot of water. In richer countries, up to 50% of freshwater withdrawals can be used in the oil, gas and electricity production process.

Take the United States, for example. The US Geological Survey estimates that to produce and burn the one billion tons of coal the United States uses each year, the mining and utility industries withdraw 55 trillion to 75 trillion imperial gallons of water annually. That's about equal to all the water that pours over Niagara Falls in five months. In other words, about half of all water withdrawals in the United States today are used to cool coal fired electricity generating stations (It is important to note that the vast majority of this water is not consumed, it is withdrawn from rivers and reservoirs and used for cooling etc., then returned. But access to the freshwater is still vital. No water, no power station)[1] .By 2030 the United States is forecast a 40% increase in energy demand. Using current energy cooling systems, this could translate into a large increase in freshwater access needs, up to 165%, according to some analysis. The math suggests that this simply can't be done, given whom else also needs water, for example farmers or cities (or the environment).

And yet water's role in the energy value chain stretches much further than just cooling power stations. A lot of water is also required to help produce a country's natural gas and liquid fuels from raw materials. For example, the production of each litre of gasoline from traditional oil uses approximately one to three litres of water. As more unconventional energy resources become technically viable or politically attractive, water use can increase dramatically. For example, gasoline made from oil sands results in water use of around three to fifty-five litres of water per litre of gasoline. To produce oil and gas resources from conventional sources requires 3-7 litres of water/Gigajoule (GJ). Unconventional natural gas resources however require the equivalent of 36-56 litres/GJ, close to a tenfold increase. Enhanced oil recovery techniques can require 50-9,000 litres/GJ; and irrigated bio-fuel crops are the thirstiest raw energy material of all -corn requires 9,000-100,000 litres/GJ, soy 50,000-270,000 litres/GJ.

This water-energy linkage creates a conundrum. The search for a secure and clean energy future to power the economy may ironically speed up the arrival of a water insecure future that will undermine future economic growth. For these reasons, General Electric has asked if there

[1] Note that nuclear power stations require more water for cooling than coal fired power stations using traditional thermoelectric generation with closed loop cooling. A megawatt hour (MWh) of electricity from coal uses 2 - 270 liters of water at the coal mining stage and 1,200 - 2,000 liters when the energy in the coal is converted to electricity. Nuclear energy uses 170 - 570 liters of water per MWh during the mining of uranium and production of the reactor fuel and an additional 2700 liters per MWh as the energy from nuclear fission is converted to electricity.

will be enough water in the United States to power the future. The Economist has written about the end to farming in the California valleys as a result of water shortages and water reallocations. In the future, to meet its energy needs, the United States may have to depend on other countries agriculture (in other words on other countries water) to import Californian orange juice and Texan steaks etc.. Even the US Department of Energy recently told Congress that energy production in the US is at the mercy of water availability.

This water for food versus water for energy dilemma which the US already faces is similar to that which many fast growing economies will have to tackle very soon. As much of Asia urbanizes and industrializes (and is encouraged to pursue lower emission or unconventional energy choices) more of their water will need to be allocated toward energy and away from agriculture. Modeling by Columbia University Water Group for the World Economic Forum suggests a 76% increase in water demand for energy and industry will be required across Asia by 2030 compared to today. Recall that this will occur at exactly the same time as these countries will also need to almost double their food production. Against a baseline of 70% of water already being used for agriculture, how can these competing economic challenges be squared off?

The answer will be that more countries will need to rely on trade to meet their agricultural needs. As economies expand, governments have to choose whether to allocate water to agriculture or to uses with higher economic value per liter, such as energy, industry and manufacturing. Many rapidly industrializing economies in relatively water scarce regions across South Asia, the Middle East and North Africa, which must create jobs for their fast-growing populations, face this challenge. Jordan, for example, historically allocates about 80% of its freshwater to agriculture; yet agriculture contributes less than 10% of GDP. To modernize its economy and create jobs, more water must be reallocated to industry, manufacturing and tourism. This means traditional agricultural patterns will have to change and Jordan must become food sufficient through imports. As many countries like Jordan structurally change their economies away from low margin rural activities and toward higher value manufacturing, they will reallocate water away from agriculture and toward energy and industry. Their economies will grow, but they will rely more heavily on agricultural imports to be food sufficient. Global modeling of this trend suggests that by 2030 nearly 55% of the world's population may be increasingly dependent on food (i.e. water) imports.

These trends illustrate a less well-recognized economic relationship between water, food, energy and trade. To grow, many economies shift their water allocations away from farming and toward higher value uses, especially energy production, industry and manufacturing. This means they become more reliant on food imports. To respond, the world system will need more trade flow in agriculture across more countries. However, historic trends point in the opposite direction. Agricultural exports actually decreased from 46% to 9% as a share of global trade 1950-2001 and in real terms. Furthermore, the majority of this trade takes place within a small closed "club" of countries including Canada, the EU, Japan and the United States with an average tariff of 30%. There is less trade in agriculture when we will need more, and more protectionism when we will need less. More fundamentally still, no correlation currently exists between the countries around the world that are hydrologically best suited to grow and export the world's food (Canada, Equatorial Africa, Russia, Ukraine for example) and those that actually do. Australia, China, India, Turkey and the United States represent half of the world's current top ten wheat exporters, yet all face well documented water challenges in their agricultural sectors. A profound rebalancing in agricultural trade flows may be required in the coming decades both in volume and in structure. This rebalancing will be driven both by fast-growing economies shifting water away from farming and toward industry, which will mean more demand for food imports, and by the water constraints that traditional "breadbasket" nations may have in delivering more agriculture for export.

We can see first responses to the growth challenge of the food-energy-water and (non-) trade nexus already being played out around the world, as water-scarce, fast growing economies in Asia and the Gulf seek to acquire agricultural land in water-rich countries like equatorial Africa. These so called “land grabs” are really about water. If of course our global trading regime offered more effective trade in agricultural goods, there would be much less need for such land/water deals.

This challenging scenario of water trade-offs over the next two decades should also be set against the context of today’s water management challenges. Unfortunately, the story gets worse. Due to a historical profligacy of water use, the old adage of “you wouldn’t want to be starting from here” holds true.

Many countries are extracting groundwater faster than it can be replenished (Mexico by 20%, China by 25% and India by 56%). Over 70 of the world’s major rivers now hardly reach the ocean due to extensive water diversions for human use. If current trends continue, by 2030 increasing water scarcity could cause annual grain losses equivalent to 30% of current world consumption (just as we need 70% more food). As demand continues to grow, competition for water will intensify between economic sectors, as well as between geographies.

In addition, a potentially changing climate will simply accelerate freshwater security challenges faced in many places around the world. Unlike options in energy, there are no substitutes or alternatives to water. We will simply have to adapt. Studies for Mexico, for example suggest that current freshwater withdrawals include 6,500 km3 of unsustainable aquifer draw down; and that by 2030, the supply-demand gap will grow to 23,000 km3 under business as usual. However, with potential climate change impacts factored in, and based on conservative IPCCC climate models for Mexico, this gap could increase by over 50% to 36,000 km3.

As the challenges in Mexico and the United States indicate, this is not just a problem for the very poorest nations alone. Water security will affect people in Australia, the Balkans, California, China, India, Jordan, Mexico, North Africa, Pakistan, Saudi-Arabia, the Southern Mediterranean region, South Africa, Turkey, the UK and the US among many, many other countries. For countries in the south of Europe, for example, currently facing deep-seated macroeconomic problems, the looming additional stress of an interlinked water – agriculture – energy -climate resource challenge does not bode well for future economic competitiveness if, like national deficits, it becomes a structural risk left unaddressed for too long.

For all these reasons business as usual is not an option. We cannot manage water into the future as we have in the past. Our historic economic planning on water has been extremely poor. Yet, given the timescales associated with turning things around in the water sector, the need for long term planning, and the dire conditions some countries already find themselves in, senior analysts suggest we have about ten years to act.

What is to be done?

To manage our future water needs we will require a policy rethink. For many countries and regions of the world facing water resource scarcity challenges, we will need a deeper and more integrated understanding of exactly where and how we manage the intersection of water with various other factors within the economy – such as energy options, industrialisation choices and agriculture strategies. We will need new economic analysis to optimise economic outcomes from this correlated resource allocation challenge, so as to help governments underpin how they deliver their various political objectives for the economy (whether it is jobs, GDP growth, equity etc.) in a consistently resource-efficient manner. To do this, improved data collection, fresh integrated economic modelling and new cross-cutting collaborations and institutional platforms will be required.

Recognising this "nexus" of interconnected resource risks, recognising the need to better measure and analyse it, and then optimizing the management of our natural resource use accordingly (including historically undervalued assets such as freshwater) so as to deliver a resource-efficient growth path for society – despite other political fashions – would be a significant step toward a green economy. This could have profound implications on how we organise our economic thinking for the 21st century. Accepting and acting on this challenge may lie at the heart of crafting a sustainable development pathway to 2030, broadly the timeframe within which scientists and analysts suggest economies will have to “structurally adjust” to a resource-efficient growth trajectory.

To create a practical plan for a move toward resource-efficient growth, four clear areas of action are required.

First, our access to basic information needs to greatly improve. Data currently available on the supply, demand, usage and sustainability of global food, water and energy supplies (and other related resource availability),is incomplete, disaggregated and in some cases inaccessible. Improving the accuracy, consistency and transparency of such information is an essential first step. Establishing a comprehensive approach to natural resource data collection - supply, demand and forecasts - and transparency will be critical for decision makers across the public and private sectors. A task force on data could be mobilized, to draw from all the key global agencies, national /state governments and private sector actors who have information. Could a neutral global scientific network, similar to the highly effective public-private Consultative Group on International Agricultural Research, be established to help coordinate such a program: for example, a time-bound Consultative Group on International Resource Data? With modern information systems could such an outcome-focused CGIRD be formed, with the explicit task of establishing an unprecedented cloud of resource data within 3 years, say by 2015?

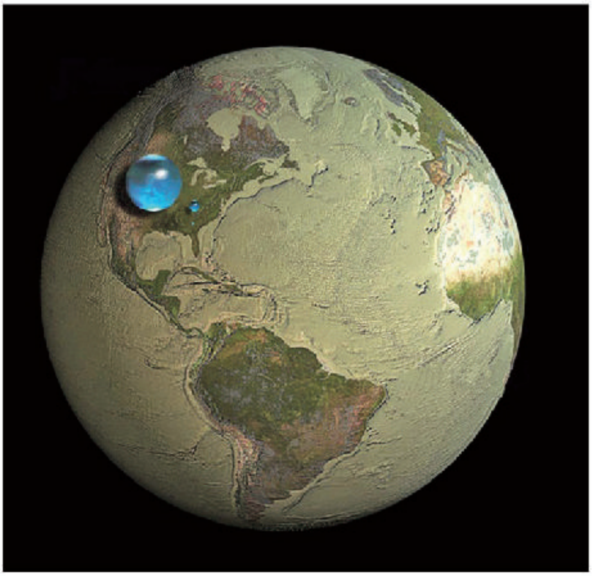
Second, our understanding of interactions and correlations between these data sources needs to greatly increase. This is so that different resource-efficient economic outcomes can be modeled. An analytical economic exercise could establish (i), what resource-efficient improvements should absolutely take place within the separate sectors of water, agriculture, energy etc.; and (ii) where do these separate sectors fundamentally intersect with each other, how do these correlations manifest themselves across the economy, and what then are the core integrated actions we need to focus on? A full understanding of the economic correlation between different agricultural, water and energy technology and policy options (and their relationship to other factors such as climatic variability, population, jobs, trade flows and commodity price fluctuations) will help develop the quantitative substance to underpin new integrated economic policy models. Sub-sovereign, national, regional and global analysis will be required, so as different layers of economic relationship can be modeled. Could a major new integrated research program for integrated analysis be formulated to undertake this work? Could sets of multi-sector “expert” task-forces from across the public and private sectors be temporarily assembled so as to support such an exercise with expertise and peer-review? Key foundations could help to catalyze such a program and ensure outcomes from the analysis are suitably framed for decision-makers and/or are designed to deliver key goals for resource efficient growth and sustainable development.

Third, the political economy for change will need to be improved, so as government action will ensue from this improved fact base and understanding of interlinks. As economic correlations become better modeled and explained, key line-ministry officials (for example in environment, water, agriculture) can become equipped with better packaged information for non-experts and policy makers as to the economic cost- benefits and trade-offs that should be made to secure a resource-efficient growth path. However, this material will not have impact, unless the political economy for movement toward resource-efficient growth policies is also shifted. Stimulating substantive policy change within and across government is notoriously difficult, especially on issues related to natural resource management. To help create a political shift, new partnerships and collaborations involving international agencies, international and domestic private sector actors, major investors, INGOs, academics and others can be of great use. These initiatives can help government content officials to bring new actors to the national growth debate (including senior officials from other parts of the Government); and they can help officials frame the resource-efficiency challenge in economic terms and within the context of the country's economic growth aspiration. New actors discussing smartly packaged economic information on the resource-efficiency challenge in a substantive manner and consistently over a period of time can help to shift the political appetite for reform. Multi-partner collaborations can be designed to help support government officials do just this, especially in developing countries where capacities may be more limited. Early work from innovative partnerships such as the Water Resources Group illustrate the potential for such scaled collaboration to help Government officials and sector professionals to catalyze change in this manner.

Fourth, institutional changes will be required. Sets of vertically aligned sector Ministries or global institutions (for energy, food, water resources etc.) will not be adequate organizational arrangements to address these interconnected challenges. Recent developments in Qatar and Jordan, where cross-cutting national councils on water are being mooted (in order to drive sustainable growth through interlinked water, energy, food and other sector policies), illustrate institutional innovation in this space; the recently disbanded National Council on Sustainable Development in the UK offered another. Consequently, as well as analysis and collaborations to shift the political appetite for reform, a simultaneous dialogue should be struck at the national and / or international level to consider the institutional innovations that take account of these integrated issues, noting that in each case they must be supported with enhanced information on economic choices and trade offs as discussed earlier. Propositions such as cross-cutting, multi-stakeholder National Resource Councils or even specific integrated Ministries for Resource Efficiency may be worth considering for some countries with particular circumstances. At the international level, concepts such as a UN Resources Agency, a UN Council for Sustainable Development and/or a UN Resource Security Council - if framed by a set of practical, integrated global goals and supported by adequate analysis - could trigger useful debate on how best to optimally manage global growth trends given our interconnected and constrained world resources.

The Water Food Energy Nexus: A Global Perspective

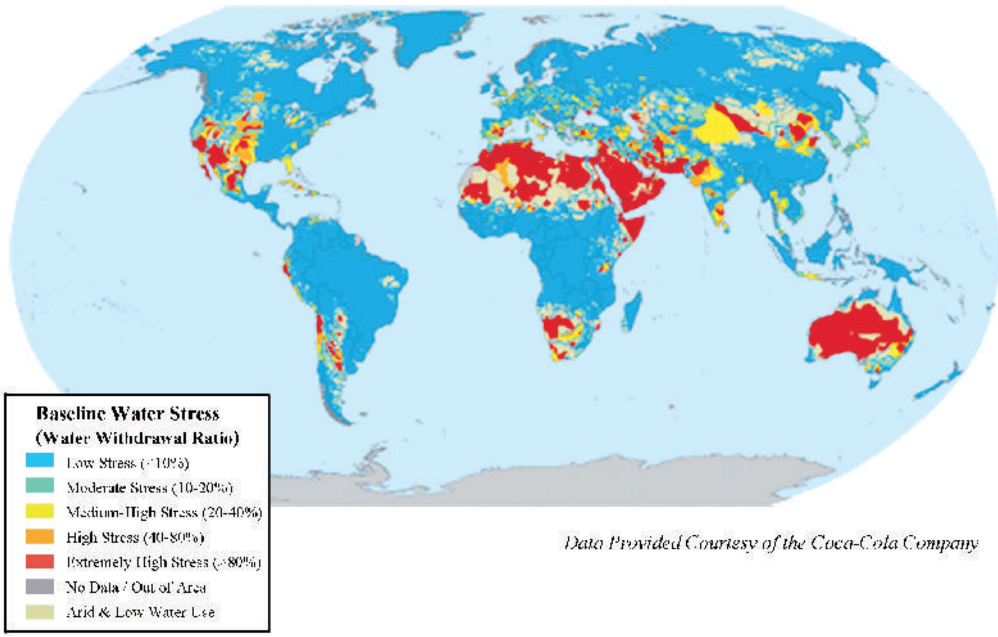
Do we face a global water shortage?



Power Point presentation by Dr. Dominic Waughray

Or a network to regional water stress?

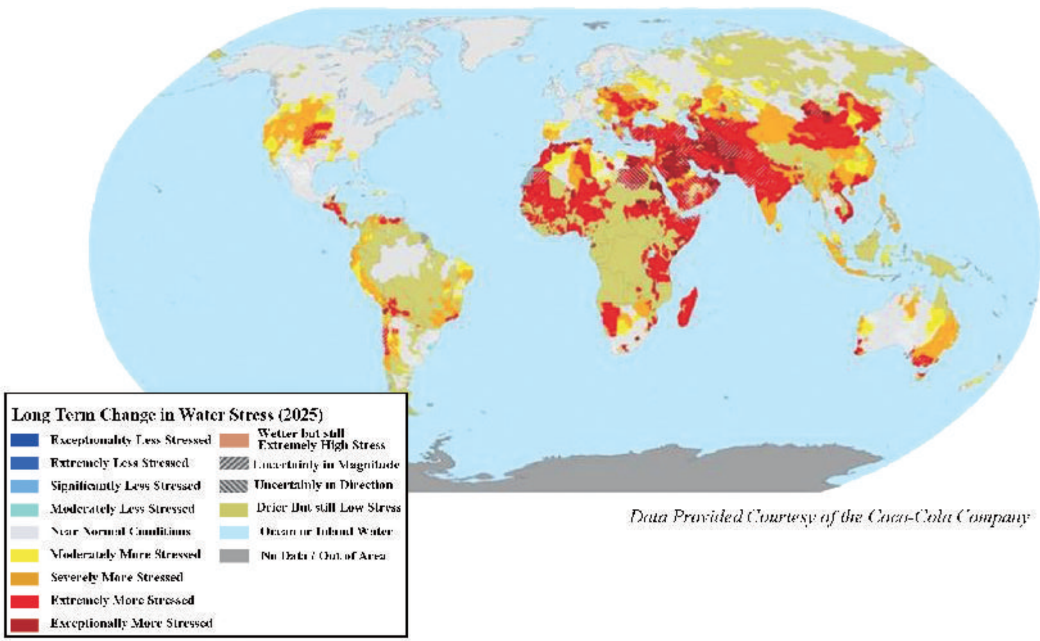
Baseline Water Stress



Data Provided Courtesy of the Coca-Cola Company

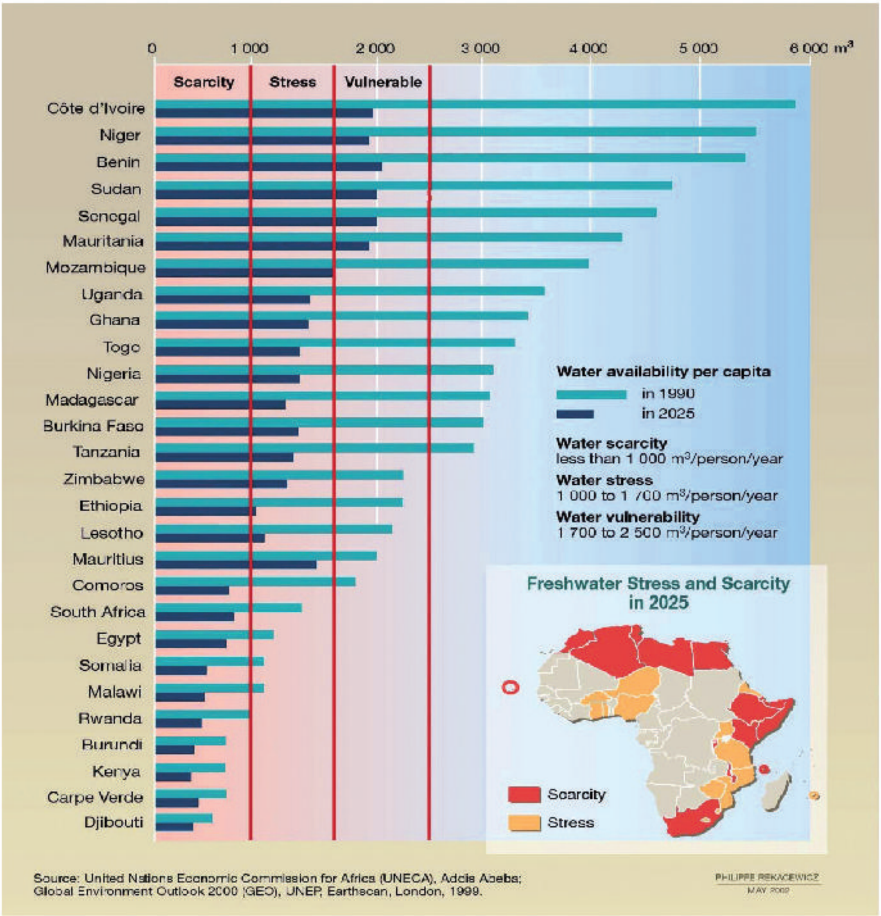
Global Water Steress 2025

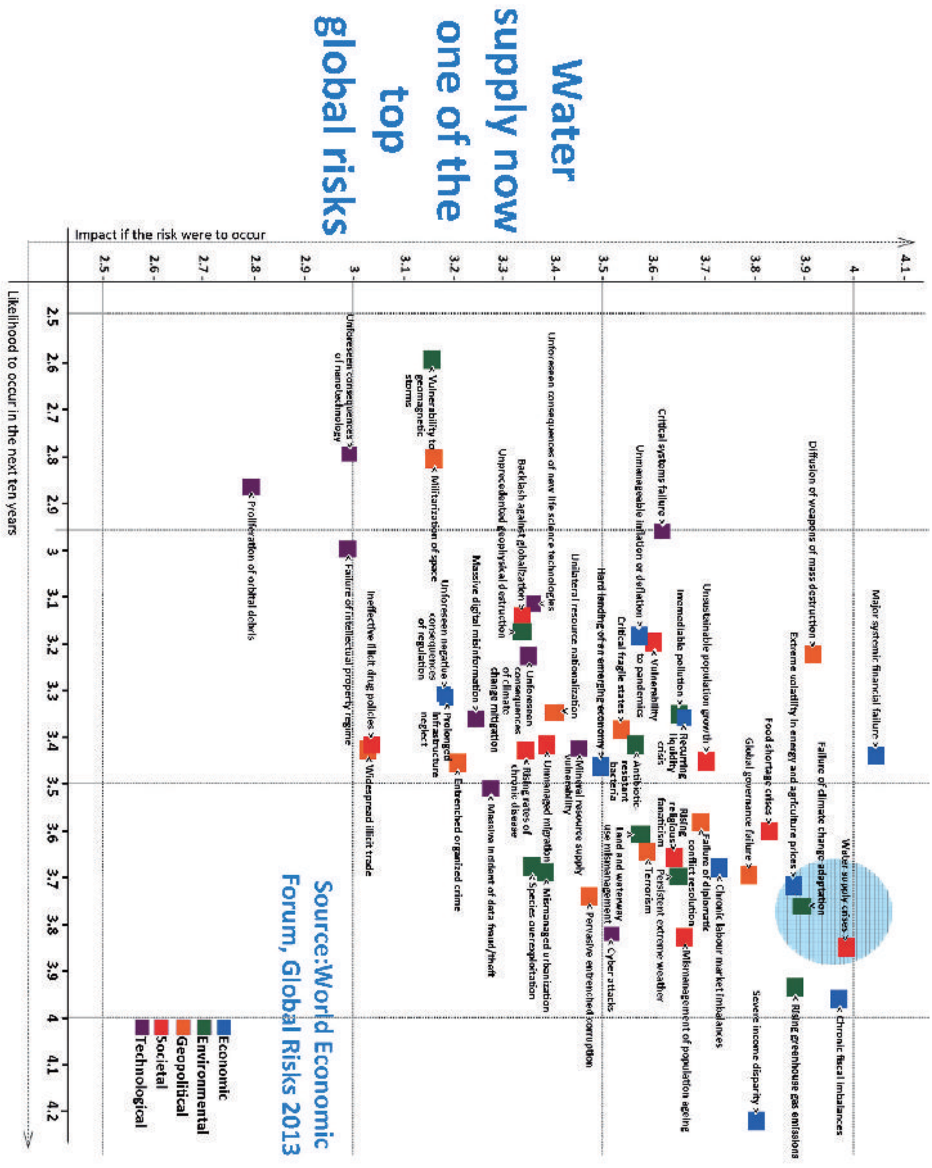
Long Term Change in Water Stress (2025):
IPCC scenario A1B



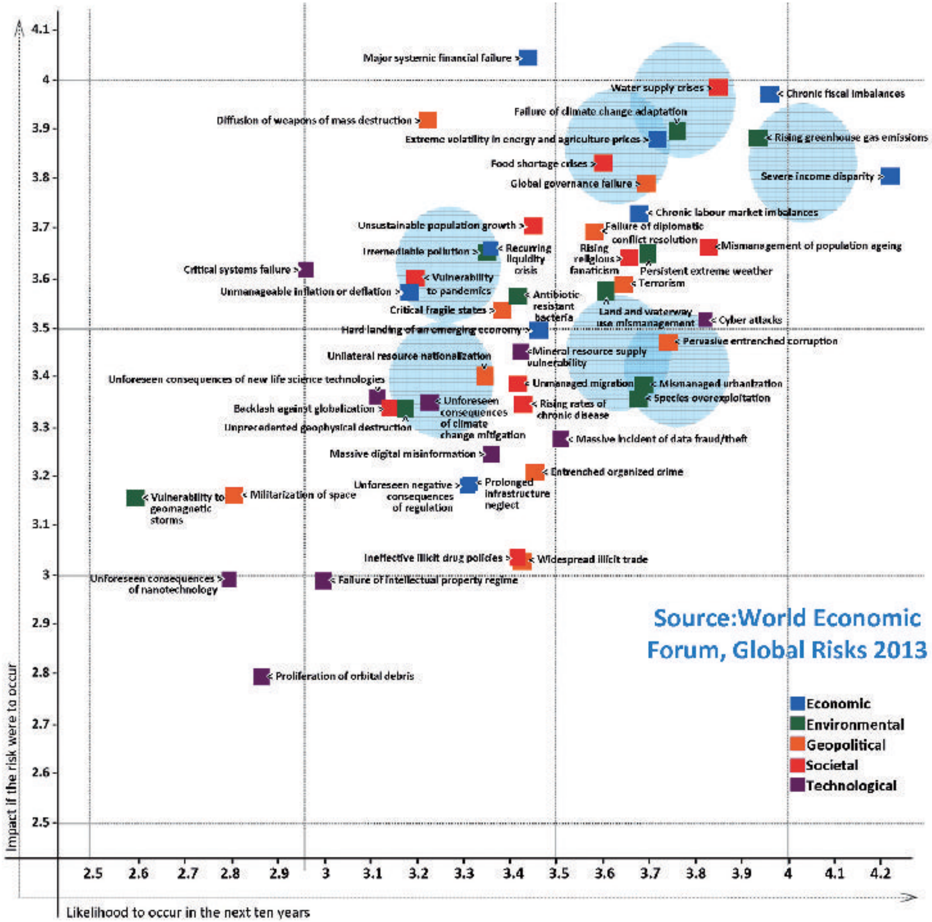
Data Provided Courtesy of the Coca-Cola Company

Water Availability in Africa




Water supply now one of the top global risks
Source:World Economic Forum, Global Risks 2013
Impact if the risk were to occur
Likelihood to occur in the next ten years
Economic
Environmental
Geopolitical
Societal
Technological
Major systemic financial failure
Water supply crises
Chronic fiscal imbalances
Failure of climate change adaptation
Diffusion of weapons of mass destruction
Extreme volatility in energy and agriculture prices
Rising greenhouse gas emissions
Food shortage crises
Severe income disparity
Global governance failure
Chronic labour market imbalances
Unsustainable population growth
Failure of diplomatic conflict resolution
Mismanagement of population ageing
Irremediable pollution
Recurring liquidity crisis
Rising religious fanaticism
Persistent extreme weather
Critical systems failure
Vulnerability to pandemics
Terrorism
Unmanageable inflation or deflation
Antibiotic resistant bacteria
Critical fragile states
Land and waterway use mismanagement
Cyber attacks
Hard landing of an emerging economy
Pervasive entrenched corruption
Mineral resource supply vulnerability
Unilateral resource nationalization
Unforeseen consequences of new life science technologies
Unmanaged migration
Mismanaged urbanization
Species overexploitation
Backlash against globalization
Unforeseen consequences of climate change mitigation
Rising rates of chronic disease
Unprecedented geophysical destruction
Massive incident of data fraud/theft
Massive digital misinformation
Entrenched organized crime
Unforeseen negative consequences of regulation
Prolonged infrastructure neglect
Vulnerability to geomagnetic storms
Militarization of space
Ineffective illicit drug policies
Widespread illicit trade
Unforeseen consequences of nanotechnology
Failure of intellectual property regime
Proliferation of orbital debris

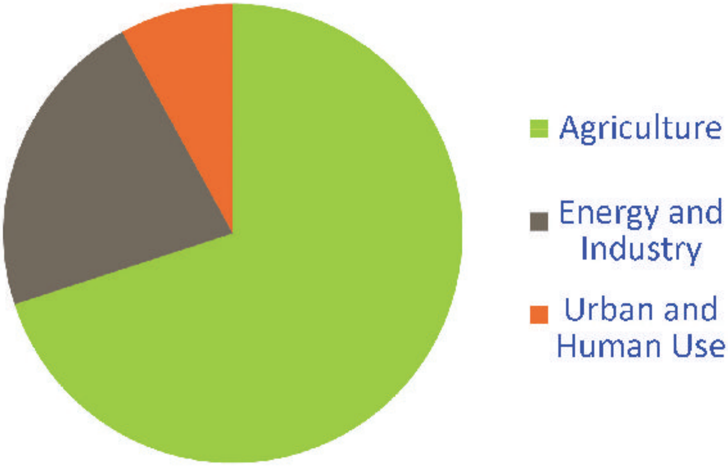
..and it's a risk multiplier



Source:World Economic Forum, Global Risks 2013

Water-Food-Energy is core to our economic foundation

Global Freshwater withdrawals



The Water Food Energy Web

1. A four-fold versus a nine-fold increase
2. A sevenfold increase 1960 to 2000
3. 40%; 2. 5 billion
4. 39% of freshwater withdrawals in the US, 32% in the EU 5. 78%
6. A decrease from 46% to 9% 1950 to 2000
7. 20 billion US$ and the size of France
8. 32 bn: 368 bn: 3.2 million barrels a day
9. 70 already
10. Gone by 2100?

The Water Web

1. A four-fold versus a nine-fold increase (population vs freshwater consumption rises, 20th century)
2. A sevenfold increase 1960 to 2000 (beef consumption, Asia)
3. 40%; 2. 5 billion (current world population without access to a toilet)
4 4. 39% of freshwater withdrawals in the US, 32% in the EU (water for for energy)
5. 78% (increase in demand for water for energy in Asia by 2030)
6. A decrease from 46% to 9% 1950 to 2000 (agriculture as proportion of global trade)
7. 20 billion US$ and the size of France ("long lease land deals)
8. 32 bn: 368 bn: 3.2 million barrels a day (ethanol production 2001, 2009, projected by IEA 2020 to provide a 5% mix in all land transport)
9. 70 already (number of world's major rivers now hardly reaching the sea)
10. Gone by 2100? (world's key glacial fields in Alps, Andes, Central Asia, Himalaya-Tibet)

Water is a “gassamer” for the economy

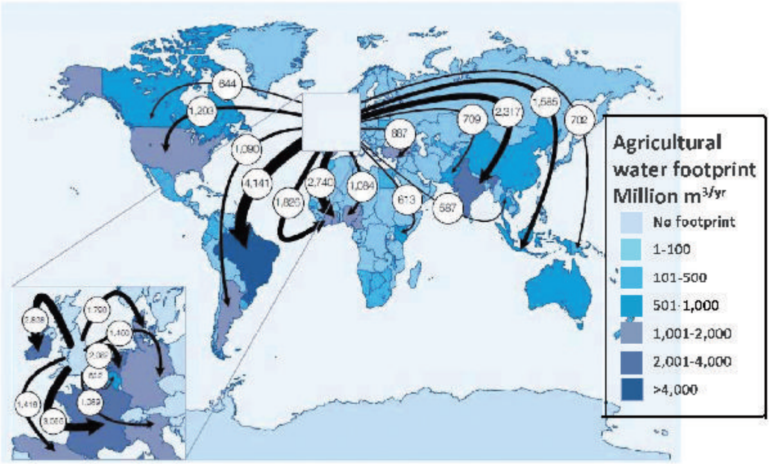
Water-Food Overview

By 2025, annual grain losses due to water stress could be equivalent to 30% of global cereal consumption

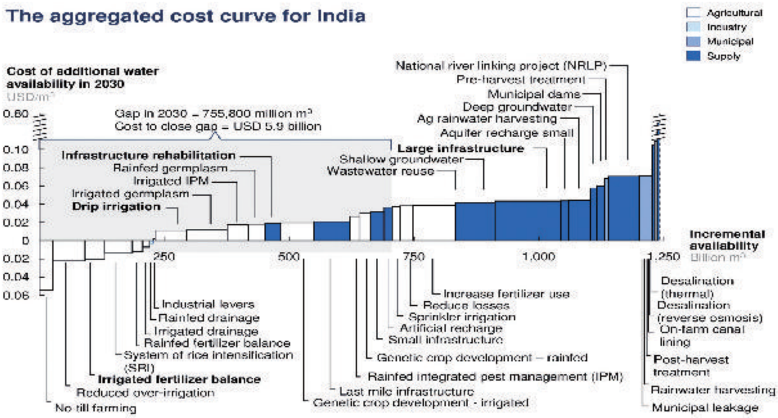
Agriculture often uses 70%+ of blue water, but with a low contribution to GDP – the economic competition for blue water will consequently increase: we will need much more crop with many less drops

A global web of water and food inter-relationships

Figure 5.4 The UK's external agricultural WF



Water Nexus and Food: India



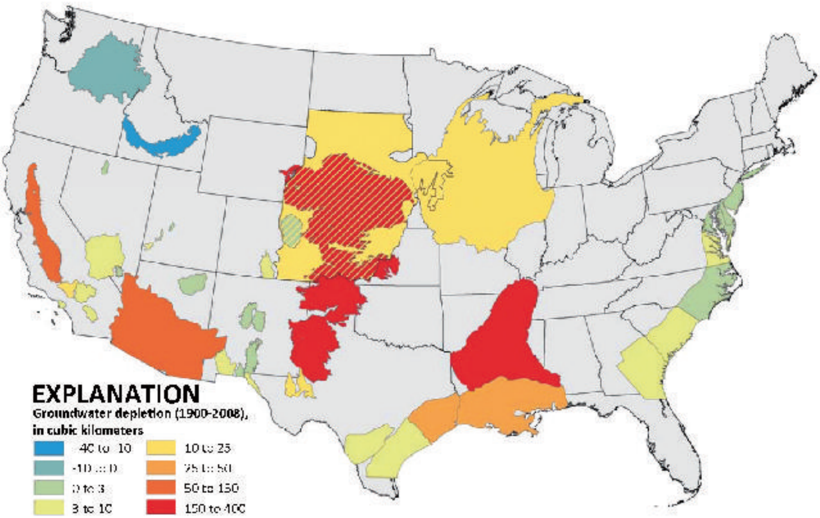
SOURCE: 2030 Water Resources Group

Water-Food Technologies

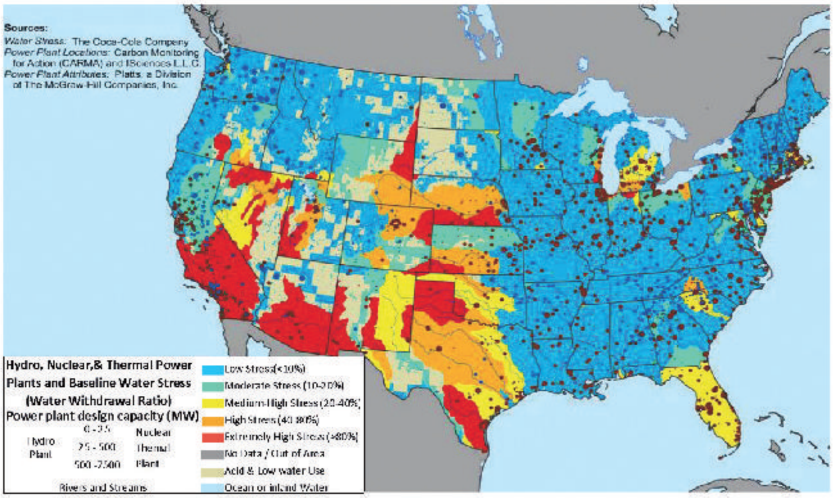
Water Availability in Africa - A Way Out?

Water Energy Overview

Historic Groundwater Depletion US 1900- 2008

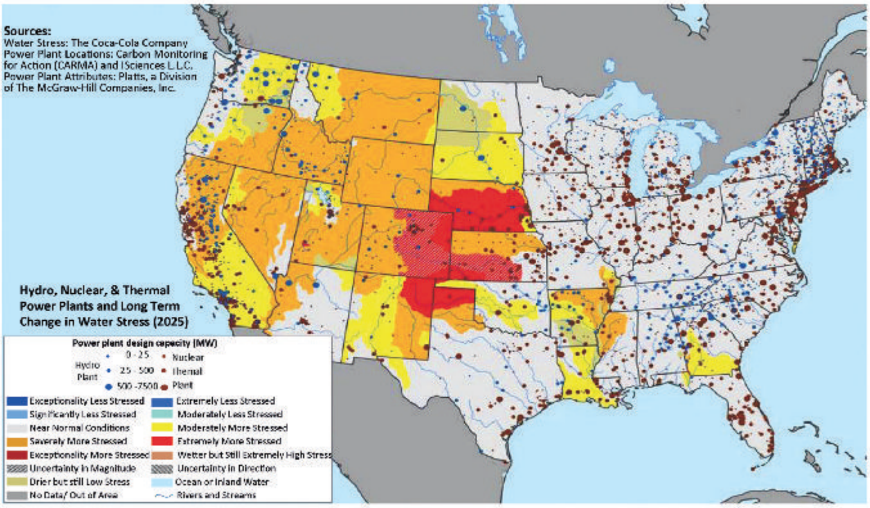


US Baseline Water Stress and Power Plants



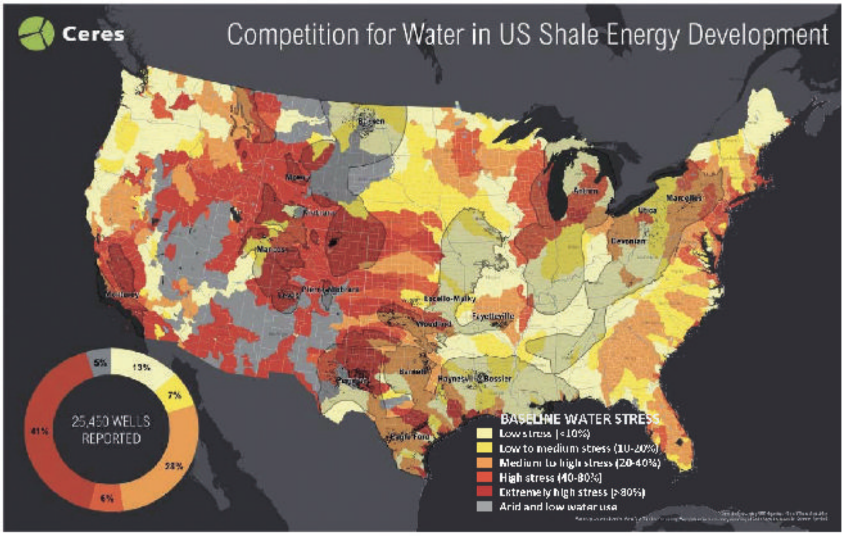
Change in US Water Stress by 2025 and Power Plants

USA, Long Term Change in Water Stress by 2025 and Power Plants
(IPCC Scenario A1B)

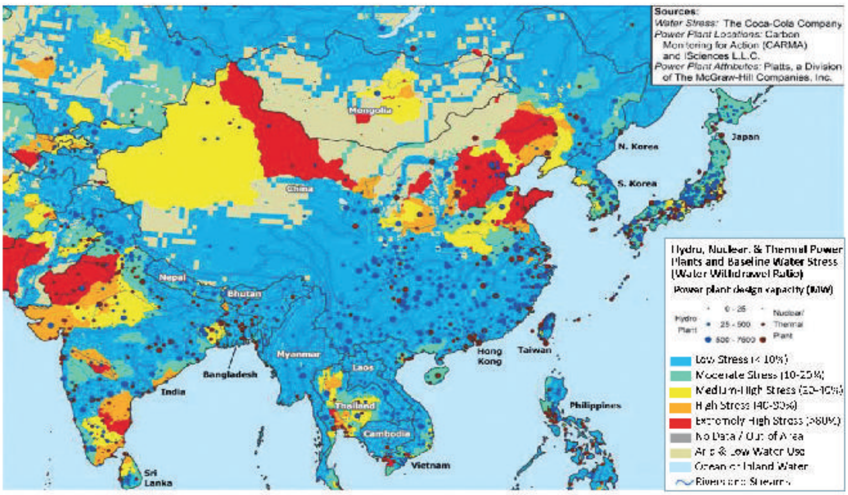


A Shale gas fracking station in Michigan

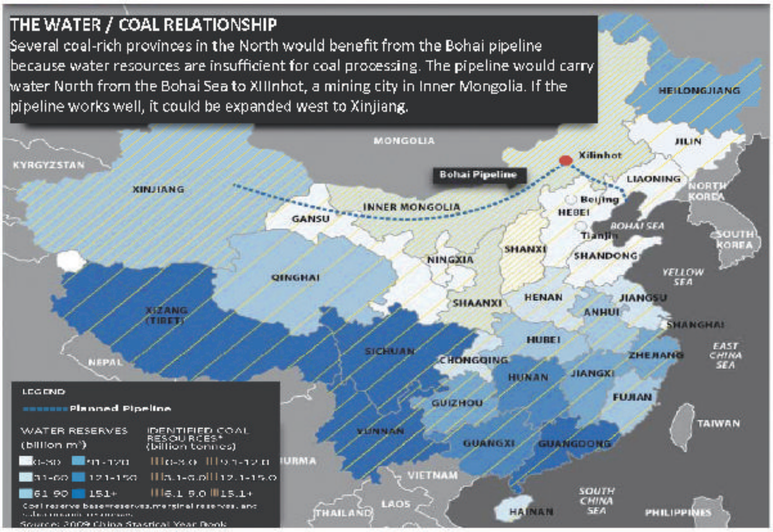
47% of fracked wells were found to be in river basins with high or extremely high risk of water stress



South East Asia Baseline Water Stress and Power Plants



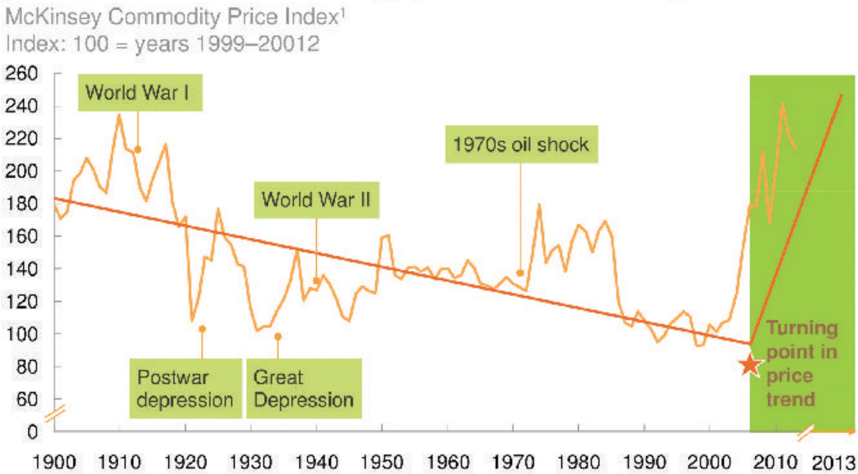
The Water / Coal Relationship in China



The nexus plays out in key regions

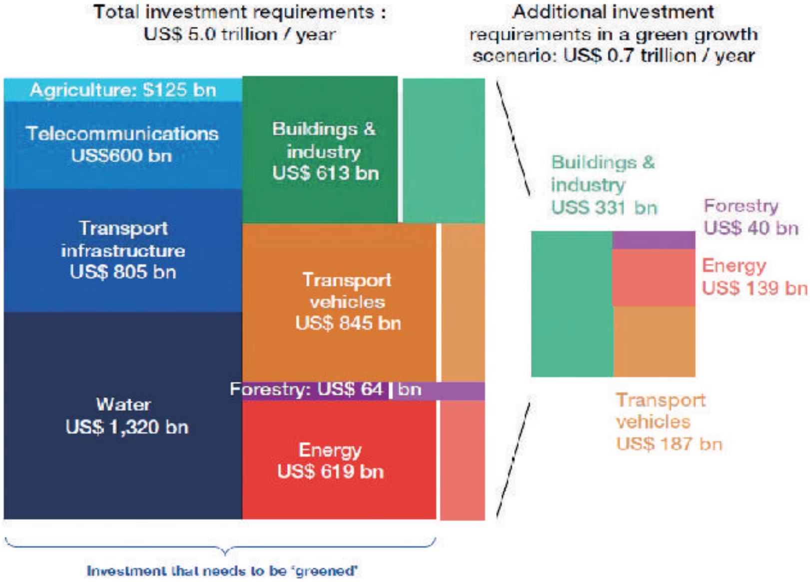
The nexus plays out in key regions

Stress on the water food energy nexus creates commodity price rise: food and energy prices most visibly affected



1 Based on the arithmetic average of four commodity sub-indexes: food, non-food agricultural items, metals, and energy.
2 Data for 2013 are calculated based on the average of the first three months of 2013.
SOURCE: Grilli and Yang; Pfaffenzeller; World Bank; International Monetary Fund; Organisation for Economic Co-operation and Development (OECD) statistics; Food and Agriculture Organization of the United Nations (FAO); UN Comtrade; Ellen MacArthur Foundation; McKinsey Global Institute analysis

WEF Green Investment Report 2013: The biggest chunk is blue



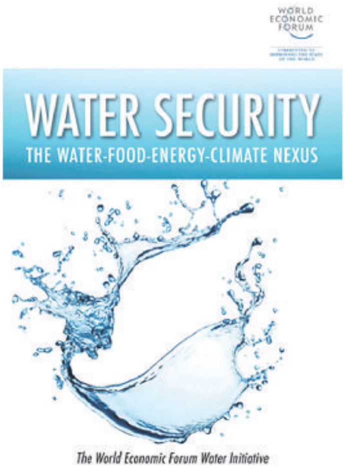
Sources: OECD[23], IEA[4], Food and Agriculture Organization of the United Nations (FAO)[5], United Nations Environment Programme (UNEP)[5]
Note: All data converted to $ 2010 equivalents

Water Infrastructure is the largest "green growth" investment requirement, but receives less attention

When risks are looked at more holistically, can water investments become nexus investments to build agriculture, energy and economic resilience

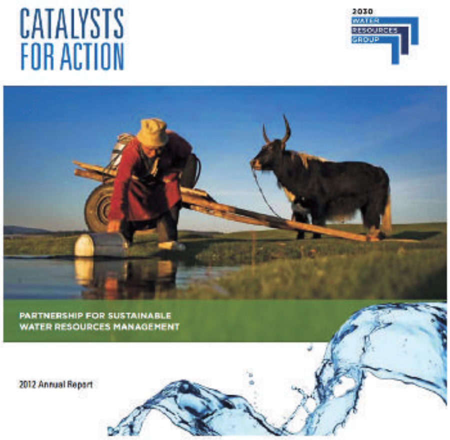
Is there a major market to make?

WEF has focused on water nexus risks since 2007



"The World Economic Forum's effort to develop the economic and geopolitical forecast on water
is essential. For the first time, all the different perspectives and expertise required to define the full dimension of the problem are brought together."

Ban-Ki Moon Secretary General United Nations



"I am convinced that under present conditions and considering the way water is currently being managed, we will run out of water well before we run out of fuel."

Peter Brabeck-Letmathe
Chairman of the Board, Nestlé SA

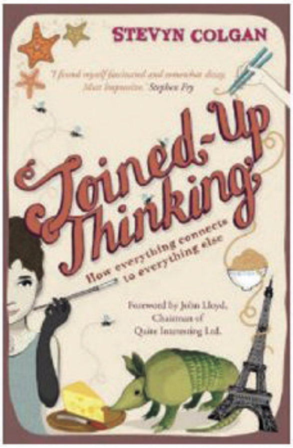
So what is to be done?

If we recognise the implications of the fast emerging water-energy-food connection...

..then this points to an inflexion point for engineering, economics and policy design collaboration...

... we will need new analysis, policy platforms and business / political networks to create a new generation of integrated decision making and investment opportunities that build economic resilience against inter-related water-food-energy risk

It's not a binary scarcity issue, it's a systems governance and management challenge



New regional /international task force on datacollection (with IEA, CGIAR)

Examine the integrated problem - a major program for econometric data modelling

Understand the need to collaborate-. The economic analysis should trigger support for scaled collaborations (cross ministerial,expert councils / regional versions) to help Governments make joined up policy changes;

Smart institutional arrangement to do this - establish institutional to 34 the reform enable the above (Ministries of Resources, Resource 30; Resource Security Council etc

جلسة الحوار
Panel Session

Rabi H. Mohtar, PhD

Executive Director, Strategic Projects, Qatar Foundation, Research and Development

Professor, Texas AM, University

Climate and Water-Energy-Food Nexus

The water–energy–food system is highly interlinked and is being stressed with population growth, economic and political risks, demographic and climate changes where barriers to sustainable resource management, including policies and public engagement, must be fully explored (Mohtar et al, 2012). Additionally, preference for measures that reduce demand over those that increase supply must be identified. Better understanding should be sought for the full life-cycle footprint of food, water and energy resources and for their products and services. It is evident that changes across nearly all sectors of the economy are expected as a result of these resource shortages. However, tools for developing multi-scale and multi-sector decisions and footprint for these resources in an integrated framework are lacking. For many years, these natural resources have relied on basic principles of predictability and stationary responses where the past was a mean to predicting the future. In this intervention, we attempt to link the real value of water, energy and food in a non stationery world. It is an effort to adopt policies to conserve water and energy. We explore the water–energy–food nexus and common integrated metrics for such a complex system.

Despite the evidence of inter-linkages between the key natural resources of water, food and energy, 'silo thinking' prevails worldwide. The need for integrated resource management is more important than ever. However, knowledge of this complex system is hampered by the fact that data, processes and integrated decision aid tools are all limited.

The inter-linkages of the water system with other systems such as food, energy, climate change, and the human system, must be explicitly defined in order to enable quantification of these linkages. Even though specific metrics must be addressed regarding the status and progress of water resources, a benchmarking tool that will address multi-dimensional water systems and their inter-relations to food, energy, and other closely related systems is yet to be established. As we explore the architecture and the implementation of the water system, various types of data help us to connect and define the interface between the separate components of this system, for both the physical and human dimensions.

Water – Energy and Food linkages:

The range of projections of temperature increase in the IPCC for 2100 (1.4 to 5.8 C) come from models that have a large uncertainty, not only in the physical models, but also in the scenarios projected for future emissions, response, technological change, population growth and other factors (O'Niel et al., 2001).

It has been reported that the projections for the sea level rise as summarized by IPCC have underestimated the change and that the actual rate of sea level rise is bigger and faster (Rahmstorf et al, 2007).

Further studies at finer spatial (regional) scale are needed. Desertification may occur in any area where the potential evapotranspiration is greater than 70% of the total precipitation. It is feasible that desertification itself can exacerbate climate change. Changes in land-use practices can affect surface temperatures through boundary changes in vegetation cover, which lead to differences in albedo and thus to temperature differences.

Much of the adaptation measures to climate change have been reactive, triggered by past or current events. It is also anticipatory and based on some assessment of conditions in the future (Wreford et al, 2010 – OECD).

Some of the major linkages of climate Water Energy Food nexus include:

- A major hike in food prices occurred in 2008 was partly directly affected by climate and weather variability, and subsequent water variability.

- Climate adaptation, as it relates to ecological zone shifts and disrupting balances that prevailed for generations. This brings additional risks and risk management to the energy-water dynamic.
- The added energy to deal with weather extremes can be huge: pumping water to areas of low rain and pumping water from flooded areas.

- With added climate change uncertainties, food security is a national security issue and must be looked at as such. However, this cannot be considered outside the nexus. Nexus solutions must be sought which are portfolios of solutions including, maximizing water use efficiency, technology, the role of green water, as well as foreign investments.

These and other linkages are further explored in the section below.

Climate Change and Food.

Impacts in the agriculture sector are heterogeneous and will have a high regional variability. The magnitude and distribution of impacts are uncertain, but all projections show a negative effect in the long term.

Climate change is projected to impact agriculture not only in the capacity of producing more food for an ever increasing demand (availability of food), but also in the stability, access and utilization of the food products.

The agroecological conditions will affect directly the suitability of land for agricultural use and the yields of crops and livestock, depending on the region.

Rise in temperatures in temperate latitudes will yield an increase in agricultural land, with longer growing periods and higher yields. In semi-arid and arid regions, the increased evapotranspiration and lower soil moisture due to higher temperatures will give a decrease in agricultural land, reduced livestock productivity and increased mortality. (Schmidhuber et al, 2007).

Mounting concentrations of atmospheric CO2 increase the yields of some crops up to 20%; at the same time, the nutritional value of produce is decreased. Impacts of higher CO2 will highly depend on crop type and management type. But it is estimated that the yield will change negatively overall with increases of temperature of more than 3 C. Also, the effects of rise in temperature and CO2 over increased pests, weeds and extreme events and their interactions are not well understood. (Wreford et al, 2010 – OECD).

The effects of doubling of the atmospheric carbon dioxide concentration was simulated to assess the global impact in crops (specially in cereal production); even with the expected rise in yields, the overall impact will decrease global crop production, with developing countries bearing the brunt of the problem (Rosenzweig C and Parry M, 1994).

The higher incidence of unpredictable extreme events is likely to affect more areas. Droughts and floods in semi-arid and subhumid areas will become more severe and more frequent, reducing dramatically crop yield and livestock numbers.

It is projected that by 2050, food prices will only increase moderately. After 2050, it is expected to increase substantially; increases in prices due to population growth and socioeconomic reasons (basically demand and population growth) will certainly outweigh the direct effect of climate change. While climate change will affect adversely food security, many studies show that the "socio economic environment in which climate change will evolve is more important than the impacts that can be expected from the biophysical changes of climate change" (Schmidhuber et al, 2007).

The overall effect of climate change in agriculture will be all these impacts individually and the interactions between each other. For example, the rise in temperature will affect crop yields, water availability and generate new pathogens and diseases; these issues are highly interlinked and thus must be addressed in tandem.

In areas where there is water stress, heat stress, or the combination of the two can make crops such as cereal very vulnerable, even to minor changes, higher atmospheric CO2

Water Resources:

The availability of global water resources, and especially freshwater, are already critically compromised in large areas. The area of land classified as very dry has more than doubled since the 1970s. By the 2050s, the area of land subject to increasing water stress due to climate change is projected to be more than double that with decreasing water stress. (Bates et al, 2008). Most projections agree that precipitation will increase in high latitudes and parts of the tropics, while it will substantially decrease in lower mid-altitude regions (arid and semi-arid).

Other impacts of the change in the mean climate such as the increase of extreme events and temperature rise will also have a direct effect on the availability of water resources. In addition to that, several studies have concluded that the rapid changes in population and socio-economic development over the next two decades will have a much stronger and immediate effect on the water and food security than it will the changes in climate (Schmidhuber et al, 2007) (Vörösmarty et al, 2000). A projection of people at risk of water shortage shows a steep change, basically as the result of urbanization and large city populations in China and India (Parry et al, 2001).

Multi-Scale and Multi Sector Approach

Nexus thinking of integration and a systems view of water, energy and food resource management must prevail at all levels. Additionally, this thinking must be based on inclusiveness for all sectors of the economy, including the entire supply chain of the nexus. For example, while developing policies and practices for water security, the most prominent stakeholders, the farmers, have been ignored. If the farmers manage the bulk of the water, water security implementation will be handicapped without their participation. The various levels of the nexus implementation include: Governance, Technology providers, Civil Society, and Private sector.

The private sector role in promoting conservation and responsible investment is critical; especially this is a new field where investment opportunities are abundant. The private sector must also play a bigger role in research and development in areas that lend themselves to further business opportunities and technology development/ enhancement.

Water-Energy-Food Nexus Tool

The **WEF Nexus Tool** is developed to provide a common space and a platform for different decision making entities to create various scenarios and predict their resource demands. A scenario is composed of the choice of food self-sufficiencies for locally consumed food products, choice of water and energy sources, as well as countries of import. The **tool output** provide a financial cost to a given scenario, quantify water requirements, local energy requirements and carbon emissions, land requirement, energy consumption through import, carbon emissions through import. The tool calculates a **"sustainability index"** for each of the scenarios and decide on a most favorable one for adoption. The tool also provides a visual comparison of different resources for different scenarios.

Ongoing activities of the nexus tool project include:

- Developed partnerships with different international research centers and government entities including Qatar, Jordan, Tunisia, Lebanon, and USA to study sustainable **food systems** and identify different stresses of climate change, changing economies, international trade, health hazards, and growing population in developing sustainable food security solution mix.

- Developed partnerships with the International Renewable Energy Agency (IRENA) to launch a Nexus Framework to allow decision makers develop scenarios of national energy portfolios and calculate trade-offs for different energy strategies.

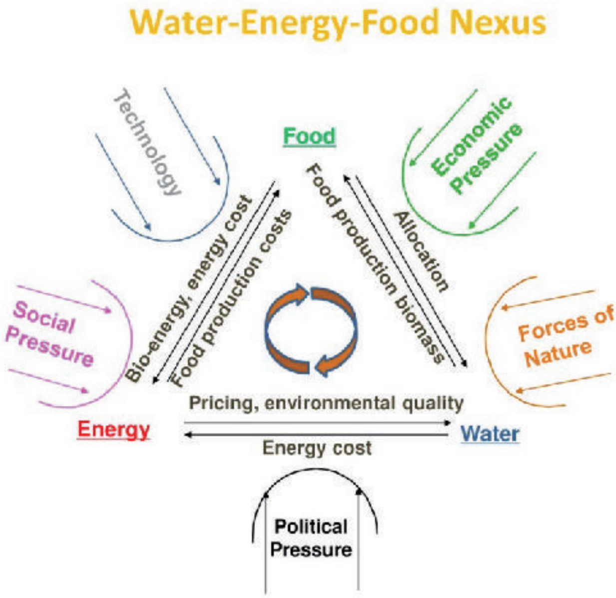
- Working with the UN FAO on decision support tools that contribute to integrative planning and management of resource. The outcome includes a **"Nexus Package"** that could be later presented to champion governments for adoption.

- Contributed to the upcoming "Global Sustainable Development Report" by UN Department for Economic and Social Affairs on

Sustainability assessments and climate-land-energy-water-development nexus. Currently, we are working with UN-DESA on global case studies in alternative energy and the WEF nexus.

References:

- Wreford, A, Moran, D. and Adger, N. (2010). Climate Change and Agriculture: Impacts, Adaptation and Mitigation. OECD (Organization for Economic Co-operation and development).
- Schimidhuber, J and Tubiello, F. (2007). Global Food Security under Climate Change. PNAS, vol. 104, no. 50, 19703-19708.
- Vörösmarty, Ch, Green, P., Salisbury, J., and Lammers, R. (2000). Global Water Resources: Vulnerability from Climate Change and Population Growth. Science. Vol 289, 284-288.
- Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof (2008) Climate Change and Water. IPCC Technical Paper VI, Geneva, 210 pp.
- Rahmstorf, S, Cazenave, A., Church, J., Hansen, J., Keeling, R., Parker, D., and Somerville, R. (2007). Recent Climate Observations Compared to Projections. Science. Vol 316, 709.
- Rosenzweig, C., and Parry, M. (1994). Potential Impact of Climate Change on World Food Supply. Nature. Vol. 367. 133-138.
- Parry, M., Arnell, N., McMichael, T., Nicholls, R., Martens, P., Kovats, S., Livermore, M., Rosenzweig, C., Iglesias, A., and Fischer, G. (2001). Millions at Risk: Defining Critical Climate Change Threats and Targets. Global Environmental Change. Vol 11; 181-183.
- Mohtar, R., and Daher, B. (2012). Water, Energy and Food: The Ultimate Nexus. Encyclopedia of Agricultural, Food and Biological Engineering. Second Edition.
- Darwish, M. and R. Mohtar. Water-Energy-Food Relation in GCC. 2013 Reports of the Arab forum for environment and development (AFED). In press.
- Bridging the food gap, GCC Agriculture, Economic Research, March 2010, http://farmlandgrab.org/wp-content/uploads/2010/05/20100301163254eGCC-Agriculture-Sector-March-2010.pdfal



Power Point presentation by Dr. Rabi Mohtar

Nexus Discussions on Global Stages

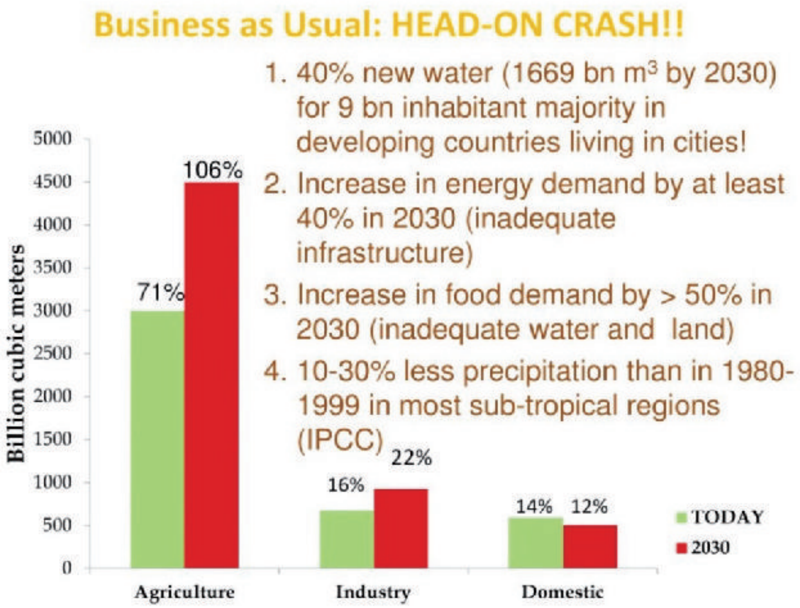
***Bonn conference** (2011) focused on **interdependency** of **water**, **energy**, and **food security** to "explicitly identified in decision making".*

*•**Rio+20** highlighted the linkages between water, food security and nutrition and sustainable agriculture; sustainable cities; health; biodiversity; desertification etc.*

*•**UNFCCC** Executive Secretary during **COP18** described the **food-water-energy nexus** as the "human face" and **solution to climate change** (WMO, 2012).*

*•UN **Secretary General** highlighted the use of a **nexus approach** and urged the inclusion of environmental, social and economic dimensions (GIZ, 2012).*

*•**Risk in Focus** 3, the Water-Food-Energy Nexus, WEF Pubs Nexus Discussions on Global Stages*



Energy Required to Deliver 1m^3 of Clean Water From Different Sources

Source	Energy required (kW-h/m3)
Lake or river	0.37
Groundwater	0.48
Wastewater treatment	1-2.5
Wastewater reuse	0.62-0.87
Seawater	2.58-8.5

Scientific American: Cramwhinkel, J. F., 2011

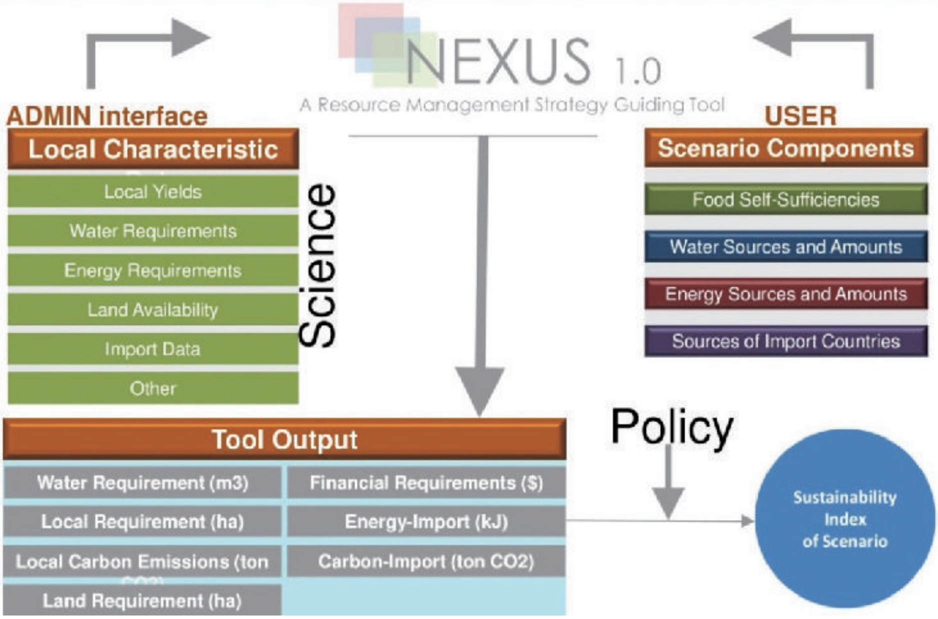
Problem Statement

Decision makers, in general, do not have access to comprehensive tools that:

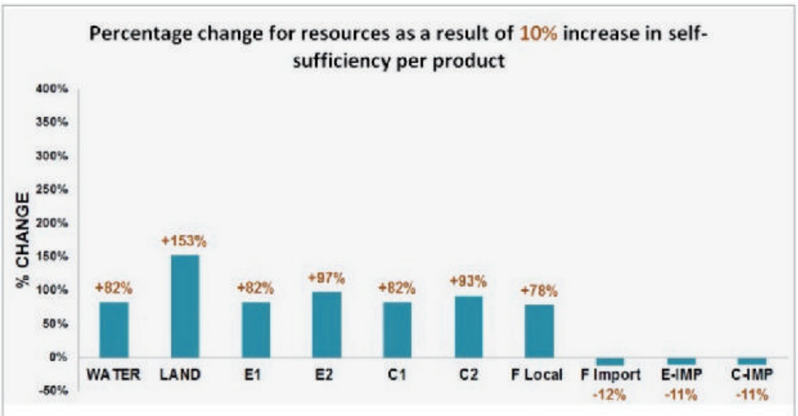
1. Quantify relationship between water, energy, and food,
2. Define their interconnectivity, and
3. Develop a strategy that allows integrative management and planning for the future of these resources,

Thus posing a threat to socioeconomic sustainability and resilience of global resources.

Web-based WEF Nexus Tool



Sample Outcome



Closing Remarks: Science

1. **Identify and quantify linkages** of the "Water System": food and energy
2. Create a global **Water Knowledge Hub** that is relevant, visible, credible and at low cost.
3. Establish **"water value"** as an economic, social and political good.
4. Deploy **tools for managing and planning water resources and risk management strategies**
5. Deploy technologies to improve **water use efficiency** at local and regional scales.
6. Understand water physical and human systems for **improved science based decision making**.

Closing Remarks: Policy

1. No **fuel from food**
2. Consider **non-stationarity** in policy decisions
3. Improve resource **conservation** & awareness
4. Facilitate dialogue of **policy makers & scientists**
5. Include **all stakeholders** in water discussions
6. Create **intergovernmental structures** for water
7. Promote **nexus friendly** & site specific tech
8. Develop local **capacity for R&D in** sustainability
9. Develop **renewable** sources of energy
10. Regulate **virtual water** and water trade

Panel Format and Objectives

Objectives

1. Highlight the nexus interconnectedness in the context of Lebanon and the region
2. Engage a multi- disciplinary audience in the nexus discussion
3. Recommend nexus future science and policy issues

Format

Short statements by distinguished panelist followed by general Question/Answer

Mayada M. Baydas, PhD
Executive General Manager
Imkan Finance s.a.l.

Status of Microfinance in Lebanon and Linkages with the Water, Energy and Food Nexus

GENERAL ECONOMY

Against all odds, the Lebanese economy continues to withstand not only the harsh repercussions of a 15-year civil war (1975–1990), but also continued unrest, military clashes, and political strife. The situation is exacerbated by the political turmoil in the region and socio-economic problems resulting from the influx of displaced from neighboring countries. The economy suffered a major contraction in aggregate demand in consumption and investment after the assassination of Prime Minister Rafik Hariri in February 2005, and has not yet recovered due, in part, to continued political tensions among the local political parties and the war with Israel in 2006. Combined with an aggressive reconstruction process after a decade of physical infrastructure destruction and financial system contraction, the Lebanese economy remains stagnant due to significant public debt.

Despite this bleak picture, the standard of living in Lebanon remains higher than countries facing similar political and economic challenges. The GDP per capita was estimated at US15,600 in 2012.[1] The GDP composition continues to be heavily reliant on services (76 percent), less on industry (19 percent), and to a small degree on agriculture (5 percent). An estimated 1 million foreign workers from neighboring Arab countries and low-income Asian countries, largely occupying blue-collar jobs, supplement the labor force of about 1.5 million Lebanese. Lebanon's official half million Palestinian refugees have limited access to public services and are heavily dependent on the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA). Syrian refugees today face a set of tough constraints due to political divide in the country.

Unemployment is estimated at approximately 13 percent, with some one third of the population living below the poverty line.[2] Nonetheless, the Lebanese economy continues to be a private liberal economy that allows ample mobility for both labor and capital.

Microfinance in Lebanon

Lebanon has about 24 microfinance programs; however, few are fully dedicated Microfinance Institutions (MFIs) working according to international best practices. When compared to the exponential growth that the microfinance industry has witnessed in the MENA region over the past 15 years, Lebanon's microfinance sector has trailed behind in outreach; the country's MFIs currently serve at best about 80,000 active clients.

As of yet, no government legislation exists regarding the regulation of MFIs in Lebanon, nor is there any specific legislation governing NGOs' implementation of microfinance programs (which constitute the majority of micro lending operations in the country). As a result, MFIs find themselves operating in a somewhat ambiguous and even

1. CIA Factbook; www.ciafactbook.org ; PPP stands for purchasing power parity.

2. United Nations Development Programme (UNDP), "Poverty, Growth and Income Distribution in Lebanon", 2007.

precarious environment in which policy makers who are not microfinance experts could be involved in setting future credit policies to regulate them. In the absence of a microfinance law, Lebanon's MFIs usually follow the laws that govern their particular legal structure, namely the NGO law, the cooperative law, and the commercial law.

Lebanese law does allow for the establishment of non-bank financial institutions supervised by the Central Bank, which could provide MFIs a transitional platform as they outgrow their NGO structures. In the meantime, microfinance NGOs, like all NGOs in Lebanon, are supervised by the Ministry of Interior. By default, the Ministry serves as the main regulator of NGO-run microfinance programs. The Ministry does not employ specifically-trained microfinance supervisors to oversee MFIs, nor does it require MFIs to use a specific accounting system.

In an attempt to support the microfinance industry, the Central Bank issued Circular Number 8779 in July 2004, regarding lending to or through NGO MFIs in Lebanon. The Circular stipulates that commercial banks can use up to five percent of their mandatory reserve requirements to fund microfinance-related activities. The objective of the Circular is to encourage commercial banks to engage in microfinance activities by granting them the option of investing part of their mandatory reserves in income generating activities, rather than leaving it all in non-interest bearing accounts at the Central Bank[3]. Despite this incentive, the Circular has resulted in very little investment in microfinance since most microfinance portfolios, whether with the banks or NGOs, are in U.S. dollars while the circular stipulates that the exemption applies to microfinance loans in Lebanese Pounds.

---

3. As of May 2008, the consolidated deposits of commercial banks deposits amounted to LBP 32,751.84 billion
($21.83 billion). Given the extremely high dollarization rate of deposits (77 percent), this yields a very limited legal reserve base (estimated at 15 percent of Lebanese Pounds deposits).

THE DEMAND FOR MICROFINANCE IN LEBANON

While estimates vary widely as to the size of the potential market for microfinance in Lebanon, they mostly indicate relatively conservative figures. Estimates by the World Bank in 1998, suggest a total market size of 43,000 clients,[4] while in 1997, the UNDP and United Nations Capital Development

Fund(UNCDF) estimated the market for women alone to be between 40,000 and 80,000, respectively.[5] In 1999 , the United Nations Economic and Social Commission for Western Asia (ESCWA) estimated the market at 125,000 clients. The UNCDF report: Microfinance in the Arab States (2004) provides the most recent estimate of potential market size, calculating market demand using the total population figures and poverty statistics. Accordingly, the study estimates that as many as 76,131 households make up the potential demand for microfinance services.[6]

All of the above estimates are based on assumptions using secondary statistics of the labor force and the population. The broad discrepancies are due to differences in the assumptions and the lack of consensus on the size of informal sector activities, especially in the Palestinian refugee camps where micro entrepreneurs are very active. Some MFIs have carried out their own studies to estimate the potential microfinance market; however, these studies remain confidential and for internal use only. Nevertheless, based on the high entrepreneurial spirit that distinguishes the Lebanese people in the region, and an economy that is dominated by the service sector, the potential size of the microfinance market should far exceed the aforementioned calculations.

---

4. http://www-wds.worldbank.org/external/default/main?pagePK=64193027&piPK=64187937&theSitePK=523679&menuPK=64187510&searchMenuPK=64187283&theSitePK=523679&entityID=000094946_01110204011534&searchMenuPK=641872 83&theSitePK=523679
5. http://www.uncdf.org/english/microfinance/docs/country_feasibility/lebanondb.pdf
6. UNCDF, microfinance in the Arab States: http://uncdf.org/english/microfinance/pubs/thematic_papers/arab_states- intro.php

With a current market outreach covering about 80,000 clients, there is a significant gap between the supply of microfinance and potential and growing demand in the market.

Of the 24 existing MFIs, the majority were established in the late 1990s as programs of large NGOs. The three largest MFIs today are AMEEN S.A.L., Al Majmoua and Emkan Finance. These three MFIs play a dominant role in the market, commanding a combined market share of no less than 75 percent as of the end of 2013. With respect to the product lines and the range of services offered by the various MFPs, most remain microcredit focused, as is the case with other countries in the region. This limitation is mainly due to the absence of an appropriate regulatory and legislative environment in which broader services such as savings could be offered. The Central Bank and its specialized supervisory commissions continue to regulate deposit taking only by banks. Additionally, products such as micro insurance simply have not been piloted and offered in Lebanon, and only recently have MFIs such as Al Majmoua begun offering business development services.

THE MICROFINANCE PROVIDERS

As noted above, the MFIs in Lebanon operate under a variety of legal structures. Many of the MFIs were formed by local or international NGOs to provide microcredit as one of a number of socioeconomic development activities. Credit is often provided at below market interest rates. However, some MFIs have been established to work in partnership with commercial banks and/or to collaborate with the credit guarantee facility Kafalat.

Some commercial banks have also implemented agreements with the Economic and Social Fund for Development (ESFD), a quasi-governmental entity managing funds from the European Union for support of the Small and Medium-sized Enterprises (SME) sector.

INDUSTRY VOLUME AND PERFORMANCE

The leading MFIs have active clients in both rural and urban communities. The three leading MFIs-Al Majmoua, AMEEN, and Emkan-generally follow international microfinance best practices and have sophisticated, accurate reporting systems. The rest of the MFIs, especially those with a social-focused mission and subsidized interest rates, track only a fraction of standard industry performance indicators such as those related to amounts disbursed and number of beneficiaries.

SCOPE OF PRODUCTS AND SERVICES

The primary product provided by all MFIs is microcredit offered largely to micro-entrepreneurs and in some cases to low-income, employed individuals. A few providers offer other loan products, such as home improvement and agricultural loans. In terms of sectors of operation, the majority of the loans are used in services, followed by trade, manufacturing, and, finally, agriculture. In terms of lending methodologies, most MFIs use both group solidarity and individual lending. Finally, none of the organizations offer voluntary savings; longer, fixed, or contractual deposit services; or insurance products.

MAJOR SOURCES OF CAPITAL

In terms of sources of capital, MFIs largely rely on the use of their own donated loan capital as revolving funds. NGOs continue to receive small amounts of funding through various donors, but remain dependent on founding members and local corporate donations to fund their operational expenditures and loan capital requirements. While most of the MFIs have received donor funds to start up or expand their operations, as noted above, several are also leveraging funding from the domestic financial sector.

SUSTAINABILITY

The three leading MFIs (AMEEN, Al Majmoua and Emkan

Finance) have reported to achieve both operational and financial self-sufficiency. These MFIs have also been reporting regularly to the Micro-Banking Bulletin for the past few years. While the smaller MFIs remain focused on achieving their social development objectives, they still hope to provide sustainable microfinance services and strive to make progress toward operational sustainability. In the case of the small MFIs, microcredit is usually just one of the services they provide as part of an integrated approach to development, typically at subsidized interest rates. This approach has limited the ability of these smaller providers to achieve full sustainability in their microcredit operations.

COMPETITIVENESS OF THE MICROFINANCE SECTOR

The level of competition in the microfinance sector in Lebanon is low, leaving ample room for movement in the market. Competition is not a major concern for most MFIs; rather they are more concerned with the country's political and economic stability, as well as their limited internal resources (human and management information systems). For these reasons, growth in the industry has witnessed only a modest growth over the past five years, including a lack of product and service innovation and diversification within the industry.

CHALLENGES FACING THE MICROFINANCE SECTOR

It is evident that there is still significant room for growth within Lebanon's microfinance industry, given the sizeable unmet demand. The potential market for microfinance has only increased in the aftermath of July 2006 war, as poverty and unemployment levels have risen, in some places dramatically. While the slow growth of the sector could be attributed partially to political and economic instability, the existing MFIs need to improve their internal capacities and develop more innovative approaches to actively promote their products and services.

ANALYSIS OF THE LEGAL AND REGULATORY FRAMEWORK AND THE STATE OF MICROFINANCE IN LEBANON

While the legal and regulatory framework for the financial sector in Lebanon is well developed, it falls short of addressing the operations of MFIs. NGOs continue to operate in Lebanon under a law established in 1909 that does not impose any strict reporting requirements. This framework has left most of the NGOs involved in microfinance with rudimentary financial statements that have not assisted them in attracting investment or partnerships from commercial banks. The only decree in Lebanon that addresses microfinance was issued in 2004, allowing commercial banks to invest five percent of their legal reserves in microfinance activities. After several years, this decree has resulted in minimal expansion of microfinance sector. One of the reasons for this is the limited capacity of the NGOs. This situation is not solely a result of the laws governing NGOs; it is largely due to the management and multidisciplinary mission of these NGOs. Though engaged in microfinance, the NGOs do not significantly invest in managing their portfolios or growing them. Experience in leading a sound financial and operational entity to manage microfinance funds at a large significant scale is limited in Lebanon.

Furthermore, since banks hold a majority of their deposit base in foreign currencies, they are not too concerned with five percent of their legal reserves-which apply to deposits in Lebanese Pounds only-because that pool is relatively limited. Nonetheless, a few banks have mentioned that this window has presented a small, but interesting opportunity.

Within the broad financial sector regulatory framework, microfinance operators may apply for and obtain licenses as financial institutions, which are entities regulated and supervised by the Central Bank. Today, three MFIs obtained licenses and are regulated by the Central Bank. While this presents a step forward in the development of

MFIs' legal structure in the country as it subjects those entities to Central Bank regulation and supervision, it does not add to their portfolios by much. Financial institutions cannot mobilize deposits from the public in small amounts and lend those funds, thus acting as a financial intermediary the way banks do, nor are they allowed to service any other financial transactions such as fund transfers or insurance. Thus, the financial position of a licensed microfinance financial institution is relatively limited in terms of its sources of funds, though it is in a stronger position to attract investment from equity investors or be able to leverage debt. Further examination of the possibility of developing a specialized microfinance law that addresses deposit-taking institutions is pertinent in Lebanon.

As it stands today, NGOs engaged in microfinance in Lebanon, while technically unregulated in terms of their microfinance operations, are best left as is given that their operations-in both scope and size-remain quite limited. NGOs wishing to pursue an expanded role and portfolio in microfinance seem better suited to follow prudent internal and external financial auditing practices and if possible to register as a financial institution with the Central Bank, thus stepping into the regulated financial institutional framework. The Central Bank in Lebanon, like many around the world, would not be interested-and should not be-in supervising small NGO activities in microfinance. If a microfinance law is to be developed allowing MFIs to mobilize savings, then the Central Bank would have to play an active role.

The primary donors influencing microfinance in Lebanon today are the U.S. Agency for International Development (USAID) and the European Union (EU), each to varying degrees and in differing ways. While USAID has played a pivotal role in supporting the industry, both to specific MFIs directly and to the sector as a whole through the development of a supporting umbrella organization for the microfinance sector in the country. The EU through its funding of the ESFD has attempted to support the microfinance sector (focusing on SMEs), but has had limited success in achieving any significant expansion in the supply of microfinance services in the country. This is largely due to the adoption of subsidized interest rates by the EU, which undermines their methodology and aim of achieving sustainable results.

The Lebanese government has not paid serious attention to supporting the development of the microfinance sector. Though the Central Bank directive was issued to spur increased investment in microfinance, this effort represents a mere fraction of the legal reforms needed to attract significant funding. Lebanon will require support from donors to build local government capacity and influence legal reforms, particularly in terms of effective regulation and supervision of the microfinance sector.

The Lebanese government bodies and policy makers with a solid understanding of the various needs and challenges facing the microfinance sector in Lebanon include the Central Bank and the Ministry of Economy. Though the Ministry has not played a significant role in the development of the microfinance sector today, it can serve as an ally in supporting new decrees that will advance the development of supportive laws for the establishment of deposit taking MFIs in Lebanon.

ROLE OF MFIS IN THE WATER, ENERGY, AND FOOD SECURITY NEXUS

There are significant interactions and interdependencies among water, energy, and food resources. For instance, water is extensively used in agricultural irrigation and food processing, as well as generation of electricity. Hence, actions related to one resource will likely have implications to the other two and ultimately to the environment. Creating business solutions that account for the interdependencies and potential impacts of these limited resources will help the goal of a sustainable and environmentally sound world.

At one end, it is undeniable that the role of international agencies, multinational and multi-focus large companies, as well as governments is crucial in achieving the ultimate goal of sustainable world resources. However, at the micro level, we should think of means to support and incentivize micro-entrepreneurs to pursue business innovations and practices, which incorporate environmentally-sound approaches that minimize resource utilization and collectively play a role in reaching balanced sustainability. This is where MFIs could play an important role in identifying, outreaching, and financing small emerging businesses that embrace the importance of the nexus among the water, energy, and food security sectors.

If one focuses on the issue of food security in the interconnected water-energy-food security nexus, this is probably where MFIs could have the most impact. A sizeable segment of the microfinance clientele around the world, but especially in developing countries, are highly engaged and rely to a large degree on agricultural production and the processing of food. MFIs as they expand their outreach to more micro-entrepreneurs who are in the food production and processing sector, they directly enhance the goal of reaching a secure world food supply (i.e., "availability and access to sufficient, safe and nutritious food to meet the dietary needs and food preferences for an active and healthy life")[7].More importantly, the expectations are that support organizations can guide these micro-entrepreneurs to implement holistic approaches that take into account and preserve the sustainability of the water and energy arms of the nexus. Similar targeted programs could be initiated focusing on the water or energy arms of the nexus; however, again, with expectations that interdependencies among the three arms of the nexus are clearly accounted for in this "sustainable" business model.

Governments and international agencies can play a key role in supporting and promoting such targeted support programs coupled with the expanded outreach of sustainable MFIs to yield complementary large-scale solutions addressing various resource and environmental

---

[7]. FAO. 1996. Rome Declaration on World Food Security and World Food Summit Plan of Action. World Food Summit 13–17 November 1996. Rome.

issues related to the water-energy-food security nexus. In Lebanon, such programs can be implemented within new and existing laws governing MFIs, as promoted and discussed earlier in this document.

Conclusions

The effective MFIs in Lebanon continue to be limited in number and outreach, with few MFIs following best practices. The leading MFIs continue to struggle for sources of funding while others operate within a subsidy approach and are far from achieving significant growth potential. Various factors regarding the enabling environment and the operational capacity of MFIs require attention in order to expand and improve the supply of microfinance services in Lebanon. To that end, a variety of sector-strengthening activities are recommended to be pursued including legal and regulatory reforms, training and awareness building, local and international networking, exploring alternative models for microfinance, and adopting technological innovations. The goal of such activities would be to improve performance of the sector; create a more enabling environment for microfinance; bolster the understanding and capacity of implementers, regulators, and policy makers; increase transparency among MFIs; and integrate Lebanon's microfinance sector into the global microfinance industry; enhance opportunities for the low income clientele to have improved access to food security and better integration into the vertical linkages that exist in the agricultural sector, particularly in rural areas.

To encourage microfinance activities in Lebanon that remain, from a regulatory perspective, limited, we recommend the following:

- With respect to secured transactions involving moveable assets, create a special tribunal competent to rule on matters relating to microcredit activities. This tribunal would operate on an expedited and cost-efficient basis. (Similar tribunals have been set up in the past in Lebanon.)

- Establish a special register for microcredit loans secured by moveable assets that are collateralized, similar to the register established for leasing operations. Though not used much by banks and financial institutions, the development of such a register would support the microfinance sector.

- Offer exemptions from stamp duty taxes for loan contracts granted by financial institutions, small-loan institutions, and other entities.

- Establish a reliable and feasible credit reference system with a lower threshold that includes microfinance clientele and information submitted from MFIs and other financial institutions. This new system could substantially lower the costs of lenders, expand the supply of credit for low-income borrowers, and allow low-income people to establish credit histories.

- Amend the NGO law to allow NGOs to shift to a commercial orientation the legal flexibility to do so, if they see this to be the most appropriate way to improve the growth of their services and sustainability of their organizations.

- Establish proportionate capital requirements and prudential regulations for financial institutions incorporated solely for the purposes of conducting microcredit activities (including lending and deposit taking), comparable with those established for deposit- taking banks. The development of a microfinance law, such as the one developed in Syria recently, would provide an opportunity to attract private capital into microfinance, and enhancing the quality of the microfinance services provided in the market.

- Do not impose financial regulation on NGOs engaged in microfinance. NGOs implementing microfinance programs in Lebanon (which are technically unregulated in terms of their lending operations) are best left as is because their microfinance operations are quite limited in scope and scale. NGOs wishing to expand their activities and attract investments to grow their portfolios seem better suited to follow prudent internal and external financial auditing practices, and if possible to register as a financial institution with the Central Bank, thereby stepping into the regulated financial institutional framework. The Central Bank in Lebanon, like many around the world, would not be interested—nor should it be—in supervising small NGO activities in microfinance. However, if a microfinance law is to be developed allowing MFIs to pursue a savings mobilizing function, then the Central Bank would have to play an active role.

- Create special targeted lending programs, which incentivize entrepreneurs to pursue innovations and best practices that focus on the water-energy-food security nexus.

Mahmoud Halablab, PhD
Dean, Faculty of Science & Information Systems,
Rafik Hariri University

Water Quantity and Quality: A Local & Global Overview

Abstract

Fresh water is absolutely an essential natural resource for which there is no substitute. Water is one of the simplest chemicals (H_2O) known and yet is the foundation of life on Earth. All living forms on our planet depend on water. The already stressed resource is further affected by global pollution which is negatively affecting the aquatic life forms and the health of human beings. Mismanagement, overuse and climate change pose long-term threats to human well-being and responding to these threats is a major multidisciplinary task involving environmental scientists, social scientists, engineers, policy-makers, and a wide range of stakeholders. Human activities play a major role in the behavior of the global water system and it is widely believed that today's water problems are entirely avoidable. Therefore, a joint global effort is urgently required to avert such universal problem.

This review article is aimed at highlighting the key water-related issues mentioned. Furthermore, the fragility of our environment will be emphasized. The global fate of fresh water and its microbiological

quality will be attempted in this study. The term “virtual water” will be discussed and its implications on water shifting will be highlighted. For instance, several countries, including China and India, have leased hundreds of thousands of hectares of farmland in Africa. The primary aim is to grow their crops abroad using the local water and then transporting it back for their own domestic consumption and hence saving their own water to grow food products.

Another area that will be tackled is importance of food wasted and its impact on agricultural practices. Today, we produce about 4 billion metric tonnes of food per year. Yet due to poor practices in harvesting, storage and transportation, as well as market and consumer wastage, it is estimated that 30–50% of all food produced never reaches a human stomach.

The final part of this review describes a study we carried out to evaluate the microbiological quality of vegetables grown in Bekaa Valley and irrigated by the Litani River. Lettuce and parsley samples were collected from different fields irrigated by the river. It is well established that the presence of *Escherichia coli* (inhabitant of the intestine of every human being) in a sample indicates human faecal contamination and, hence, is likely to be contaminated by disease-causing microbes. It was noted that *E. coli* was present in 42.30% of lettuce samples collected compared to 13.8% in parsley samples. In addition, *Staphylococcus aureus*, another important microbe, was detected in 51.5% of lettuce samples and in 38% of parsley counterparts. This study demonstrated that lettuce and parsley, which make a major part of our national dishes and are likely to be consumed raw, may contain microbes that pause risk to human health. Such potential risk is as a result of irrigation of the products by untreated wastewater or by production practices (manure for fertilizer) and human handling. Therefore, it is urgently required that disposal of of untreated sewage to local rivers is prohibited and that the rivers’ water is not used until it is clear from indicators of sewage contamination.

1. Water Quantity

In the next one or two generations there may well be 9 billion people on Earth and majority of whom will be living under severe pressure on the availability of fresh water. Such pressures are inflicted by mankind and are perhaps avoidable problems. If consumed sustainably there will be enough freshwater to quench the thirst of everyone. For instance, worldwide, every year about 1000 cubic kilometers of groundwater is consumed and the global groundwater recharge at 12,700 cubic kilometers per year.

"We produce about 4 billion metric tonnes of food per year yet about 30–50% of it never reaches a human stomach"

1.1. Global Concerns

The total volume of water on Earth is about 1.4 billion km^3. The volume of freshwater resources is around 35 million km^3, or about 2.5 percent of the total volume **(Fig. 1).** No wonder then Earth is described as the blue planet suggesting that there is plenty of water. However, hardly any is available for people to use. Fresh water accounts for just 2.5% of the total amount and of that, 70% (24 million km^3) is locked in ice and snow. The liquid in rivers and lakes makes up less than 0.3% (105,000 km^3) of the world’s fresh water. Around 30 percent of the world's freshwater is stored in aquifers underground in the form of groundwater. This constitutes about 97 percent of all the freshwater that is potentially available for human use.

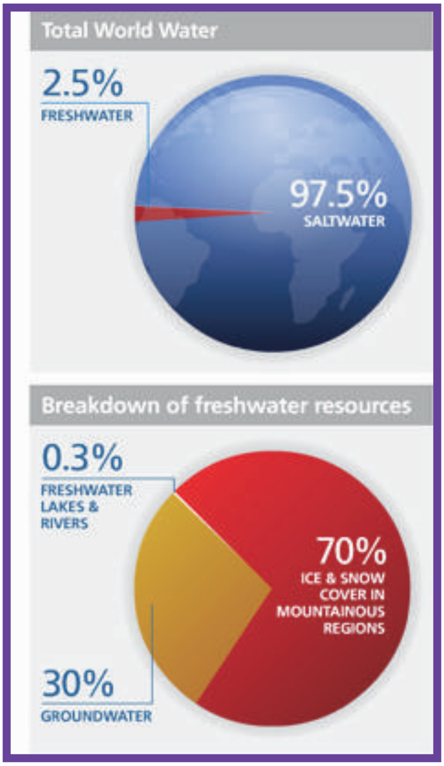


Fig.1. adapted from UN Water wesite

1.1.1. Current Aquifers

Almost half the world's population lives in 263 international river basins. The Danube, Rhine, Congo, Nile, Niger and Zambezi rivers all pass through nine or more nations. But two-thirds of these basins have no treaties to share the water. Besides rivers, underground water reserves is another issue. Aquifers are underground layers of rocks or sediments from which water can be extracted. These are normally done by drilling boreholes or digging wells. They hold 100 times the volume of freshwater that flows down rivers and streams around the world at any time. Over 30 percent (about 10.5 million cubic kilometres) of the total fresh water is stored as groundwater beneath the Earth's surface. This unseen water is the most important available fresh water resource. Lakes, artificial lakes and rivers account for far less than a half percent of the fresh water reserves.

These are one of the world's greatest and most precious natural resources, yet are entirely hidden. Aquifers hold 100 times the volume of freshwater that flows down rivers and streams around the world at any time.

"Worldwide, every year about 1000 km^3 of groundwater is consumed and the global groundwater recharge at 12,700 km^3 per year"

Many aquifers once thought of as isolated, turn out to be part of giant cross-border reservoirs. With world water use expected to triple in the next 50 years, "real wars" over water are increasingly likely, unless, of course, global treaties and agreements are properly employed. For this reason, for the first time, a high-resolution map shows where underground aquifers store vast amounts of water. The map is the result of nearly a decade of sometimes difficult talks between neighbouring governments, mediated by UNESCO. The hope is that it will help pave the way to an international law to govern how water is shared around the world.

The two largest of these mega-aquifers are both under threat from over-exploitation and could become the subject of disputes. One is the Nubian aquifer beneath the Sahara. It is being drained by Libya, to the anger of Egypt, Sudan and Chad, which it also underlies.

The other is the Guarani aquifer beneath parts of Brazil, Paraguay, Uruguay and Argentina. These countries are all drawing from what is effectively the same well.

What the UNESCO map reveals is just how many aquifers cross international borders. So far, the organisation has identified 273 trans-boundary aquifers: 68 in the Americas, 38 in Africa, 155 in Eastern and Western Europe and 12 in Asia. Each trans-boundary aquifer holds the potential for international conflict. If two countries share an aquifer, pumping in one country will affect its neighbour's water supply.

Recently, there has been an increasing reliance on aquifer groundwater simply because there is more of it and it tends to be less contaminated by industrial run-off. However, this has resulted worrying environmental consequences. For example, in many parts of the world, around the Mediterranean, in the US and the Middle East, water tables are falling and aquifers are being infiltrated by seawater as agricultural practices pump water out faster than it can be replenished by rain.

When aquifers fall between countries, sustainable management requires international agreement. Yet, historically, many agreements have been weighted towards the richest or more powerful country. The most well-known example of this is the 1995 Oslo agreement between the Israeli and Palestinian authorities. This granted Israel rights to 90% of the water contained in four aquifers (and the Jordan river) which span both territories. Hence, Israelis get four times as much water per person as Palestinians. Therefore, the UNESCO map merely helps define the geographical extent of an aquifer, which could be useful in defining international agreements. The map could also help countries better manage their water. Neighbouring governments will be able to share technologies and strategies for exploiting a shared water resource without sucking it dry.

No doubt that there is a pressing need for an international law on water sharing including groundwater. At the moment, the only legal framework is a 1997 agreement under the United Nations relating to "non-navigable freshwater resources". The document was initially drafted to regulate the use of surface water, and attempts are underway to extend it to underground resources as well.

The political intricacies of such a legal framework are considerable. For starters, aquifers fall into two gross categories: those that are recharged by rainfall permeating from the surface and "fossil" aquifers, such as the famous Nubian sandstone aquifer beneath Egypt, Sudan, Chad and Libya. These contain water that can be tens of thousands of years old, leftover of a much wetter climate. Crucially, they are not recharged by rainwater, making them finite resources.

Therefore, countries will be racing each other to the bottom of these aquifers and must agree on how to run the race. However, many countries don’t always agree and this may result in future conflicts.

On the other hand, rechargeable aquifers present an entirely different political - and scientific - challenge. The best use of the water from an environmental perspective is to use the water at the same rate as it is naturally recharged, or more slowly. This implies knowing how the aquifer is recharged and agreeing on the fairest way of sharing the water that can be sustainably extracted each year.

Early in 2000s, the Nubian Sandstone aquifer began to run into trouble. It is one of the largest and oldest groundwater deposits in the world, which supplies Libya, Egypt, Chad and Sudan and it was emptying fast. Egypt was tapping the aquifer to feed its growing desert cities far from the Nile. Libya, whose only other water source is the salty Mediterranean, was drawing water off by way of an underground network of pipes and aqueducts known as the Great Man-Made River, which Libyans describe as the eighth wonder of the world. The ancient aquifer system was just too complicated. Also, it was impossible to pinpoint who was taking too much water, or even estimate when it would run out. Because none of the countries trusted the others to provide an unbiased analysis, they couldn't agree on what steps, if any, to take to protect the aquifer. Mistrust and a lack of cooperation threatened to spiral into something worse.

This conflict exposed an ordinary truth that had somehow been forgotten: most of the world's drinking water is hidden underground, and we don't have a clue what's happening to it. But as global populations grow and climate change kicks in, one thing is certain: we can no longer count on the water to be where we expect to find it. But, we do know that our groundwater is dissipating into the ocean, being consumed at record rates and being irreversibly contaminated. Therefore, it won't be long before shortages cause widespread droughts and the first water war begins.

"The 1995 Oslo agreement between the Israeli and Palestinian authorities granted Israel rights to 90% of the water contained in four aquifers and the Jordan River"

The obvious question is how can we stop this? The first step would be to know where the water is. Conventional maps are no longer enough when you're dealing with an invisible, moving target. But there is hope. Impressive new physics and engineering tools are beginning to yield the first clear pictures of the world's hidden water. These have already revealed some unexpected good news, but their real promise is in the possibility of a world map of a resource more precious than oil.

Most people would be surprised to hear that. After all, it's been easy enough to exploit the water hidden in aquifers. These underground stores are vast; the 40,000 cubic kilometres of water in the Guarani aquifer in South America, for example, far exceeds what's in all five of North America's Great Lakes. But this water isn't held in a vast underground lake. Instead, it moves, often slowly, through complex layers of permeable rock, sand and other geology. And unlike a lake, how useful it is depends not only on how much water it contains, but on how quickly it is refilled by rainwater or snowmelt.

There are plenty of maps that determine the location of world’s aquifers. However, none make any mention of how much water they contain, how fast the water levels are changing, or even whether the water is safe to drink. As the world's population increases, so too does demand, but that isn't the only cause for concern. Climate change is gradually redistributing the world's water. As the Earth warms, precipitation is shifting from the mid-latitudes to the low and high latitudes. Wet areas are becoming wetter and dry areas drier, which may account for the record-breaking droughts in east Africa and Texas lately. Less rainfall in these mid-latitudes means less new water to refill the aquifers that are being depleted the fastest, and that means more aquifers will become like the Nubian - a precarious source in a dried up landscape.

1.1.2. Dating Aquifers

In order to figure out how much water we can sustainably take from such a fragile system, we need to know two things: how old the water is, and how quickly it is being replenished. Until recently, the only way to get that kind of data was with costly and time-consuming borehole studies. These involve digging lots of narrow wells in order to monitor the speed and direction of the water flow, and then using that data to construct a model of the aquifer. Such studies on certain aquifers, like the Nubian aquifer, would be out of question due to many reasons including political reasons and difficulty in justifying extensive sampling across four different countries.

The solution to this problem came from the International Atomic Energy Agency (IAEA) which uses isotopes to test surface water. This was an opportunity to help the Nubian aquifer in 2006. Not only is isotope testing much cheaper, because it only requires taking a few water samples from existing wells, but this handful of samples can reveal the state of the whole aquifer. In addition, measuring isotopes in one location can tell you what is happening tens, and even hundreds of kilometres away.

First, they needed to work out how old the Nubian aquifer was, and for that, the team turned to carbon-14. Just like ancient artifacts, water can be dated using this radioactive isotope. Above ground, water absorbs some of the gases in the atmosphere, including carbon dioxide, causing it to take on the atmosphere's signature cocktail of isotopes. When the water later disappears into an aquifer, it takes this unique signature with it. As time passes, the carbon-14 undergoes radioactive decay. The amount that remains in a sample of water can reveal the water's age.

It turned out that there was practically no carbon-14 left in their samples. That meant the water was extremely old **(Fig. 2)**.

Scientists then turned to krypton-81, a rare isotope that researchers have only recently learned how to trap and count, which can accurately determine the age of water back to 2 million years. It was later discovered that a good portion of the water in the Nubian aquifer is close to a million years old

To get a complete picture of the aquifer, it was important to understand whether any part of it was being refilled with new water. This was done by looking at two isotopes of the atoms that make up the water molecule, namely, deuterium and oxygen-18. Every drop of water has a telltale ratio of these two isotopes, which offers clues to the climate at the water's source. Both of these heavy isotopes decrease in cooler climates. Therefore, a sample with a lower concentration of oxygen-18 and deuterium would suggest that the last time new water was being deposited, the climate around the Nubian aquifer was cooler.

To the surprise, the deuterium and oxygen-18 in the samples confirmed that no new water had been deposited there during modern times. The aquifer contained only "fossil water" that had been trapped underground long ago. In other words, this aquifer was not being refilled and would one day run dry.

This was bad news. However, the isotope studies enabled the calculation of how much total water remained in the Nubian aquifer. It may be old, but it turned out that enough fossil water remains in the aquifer to last at least several centuries. Not only that, but, the water flows so slowly that one country's pumping doesn't immediately affect another. In other words Chad doesn't have to worry about Libya stealing its water.

"Enough fossil water remains in the Nubian aquifer to last at least several centuries"

As a result of this important study, the countries that rely on the Nubian aquifer finally agreed that they need to work together to protect it, which broke decade-long tensions. This may be extend hopes to map the world's groundwater according to age and recharge rate.

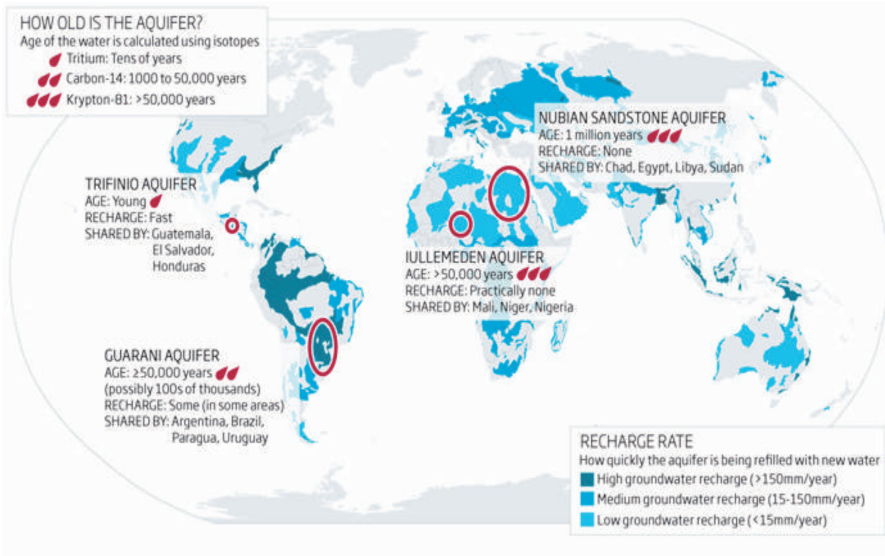


Fig. 2. Scientists turned to isotopes to determine the age of aquifers and how quickly these are replenished, if at all.

In September 2013, vast supplies of groundwater were found under Kenya. Kenya's Turkana County is notoriously dry, but a new survey now shows that it is sitting on a total of 250 trillion litres of groundwater. That is enough to support 40 million people if it is extracted sustainably.

Most of the water bonanza it discovered lies in five deep aquifers that had not been spotted before. It has been estimated that these reservoirs, in combination with shallower ones already exploited, could provide 3.45 trillion litres of water per year, in perpetuity. In addition, it could be very good news for the region. Turkana County is prone to drought, and struggles to support the famous Kakuma refugee camp, which is currently home to 120,000 people. However, before the deep extraction can begin, the Kenyan government must check the quality of the water. It might contain too much fluoride to be drinkable. It is also crucial to figure out how long it takes for the aquifers to refill, to avoid taking the water out faster than it is replaced.

It is of tremendous value to the inhabitants of dry regions where groundwater is the only reliable water resource. The yearly consumption of groundwater world-wide is calculated at 1000 cubic kilometres, and the global groundwater recharge at 12,700 cubic kilometres per year. In many countries the drinking water is mainly tapped from groundwater. For instance, in Germany it is more than 70%. In countries such as Denmark, Lithuania and Austria, groundwater is nearly the only source for public water supply.

"Kenya's Turkana County is notoriously dry, a new survey shows that it is sitting on a total of 250 trillion litres of groundwater"

Although it comprises 97 per cent of the world's accessible fresh water, we have never really bothered to get a clear picture of the water beneath our feet. Most hydrologists prefer to study the water on the Earth's surface. Around 1.5 billion people on Earth are supplied with groundwater. The importance of groundwater will grow considerably in the future, as it is a safe and qualitatively high drinking water resource. If it is used reasonably and sustainably, it can provide an important contribution in solving regional water crises on earth.

Humans are over-consuming natural resources at an unsustainable rate. Around 3.5 planets Earth would be needed to sustain a global population achieving the current lifestyle of the average European or North American. In the next two decades, the world population will be increasing and most of the population growth will occur in developing countries. This will mainly include regions that are already experiencing water stress and in areas with limited access to safe drinking water and adequate sanitation facilities.

It is important to mention that water resource management impacts almost all aspects of the economy, in particular, health, food production and security, domestic water supply and sanitation, energy, industry and environmental sustainability.

Man’s behaviour plays a major part in shaping changes to global water cycles. Countless millions of individual local human actions add up to regional, continental and global changes that have drastically shifted water flows and storage, impaired water quality and damaged aquatic ecosystems.

Humans altered the planet's climate and chemistry, its snow cover, permafrost, sea and glacial ice extent, and ocean volume. All of these are fundamental elements of the hydrological cycle. Furthermore, we have accelerated major processes like erosion, applied massive quantities of nitrogen that leaks from soil into ground and surface waters and, sometimes, literally siphoned all water from rivers, emptying them for human uses before they reach the ocean. We have diverted vast amounts of fresh water to harness fossil energy, dammed major waterways and destroyed aquatic ecosystems. These changes put us on an unsustainable path. However, current scientific knowledge cannot predict exactly how or precisely when we will breach a planetary-scale boundary, a tipping point that could trigger irreversible change with catastrophic consequences.

In an attempt to anticipate such a catastrophe and move toward a more sustainable course, some problems will have to be set and how to address them. Those problems are not restricted to developing nations. Maps of water availability per person, for instance, show hotspots of scarcity across much of Europe and North America.

For example, costs in infrastructure investments can run into hundreds of billions of US dollars. However, is this kind of money is going to be available to bring water to the poorer people of the world?

Costly hard engineering solutions such as large reservoirs and water transfers from one basin to another deliver water in rich countries. However, this might not be the best solution to rely on when developing nations are considered. An alternative would be to consider the services that healthy ecosystems can give us, among them flood protection and pollution reduction. The famous example is when New York City authorities found it cheaper to pay farmers in the Catskill Mountains to change their farming practices than to invest in new water-treatment plants. This approach could and should be investigated in many more places.

In addition, aquatic ecosystems are in danger. Of all known species, 7 to 12 per cent are heavily dependent on fresh water, and around 30 per cent of them are endangered, a far higher proportion than for other habitats.

Despite the significant amount of research carried out, one of the great problems we face is often related to the lack of most basic information. The number of monitoring stations to measure water flows and quality has collapsed, and some countries that share water resources with others, nevertheless, jealously guard the data they do have, making it even harder to manage international river basins.

"Around 1.5 billion people on Earth are supplied with groundwater"

We urgently need a new, globally integrated monitoring system, using on-the-ground and satellite technologies, and feeding standardised databases that all can use. Citizen scientists, equipped with basic training and mobile phones, could well play an important role in better water monitoring. Above all, there is a need for change in the way water is governed.

Water cannot be considered in isolation, but, as part of a water-energy-food nexus, in which each sector affects, and is affected by, the others. At the center of that nexus is human well-being, and as the world moves towards setting new goals for sustainable development, it is urged that fresh water be integrated into all of them. It is no good calling for food security or better health, for example, without realising that both depend on water security.

Although freshwater amounts are limited, adaptation of water-efficient technologies and encouragement of economic activity that doesn't use large amounts of water could overcome the problem of water scarcity. The looming water crisis is primarily a problem of distribution, overuse, and management rather than supply. And we can solve it using existing technologies, public education, increased investment and political will.

A country is defined as "water-stressed" when it cannot extract more than 4654 litres of water per person per day (equivalent to 1700 cubic metres per person per year) from its rivers and aquifers. One with less than 2738 litres available per person is classified as "water-scarce". Anything below 1369 litres constitutes "absolute water scarcity", and threatens economic development as well as human health and well-being.

Freshwater resource is unevenly distributed. There is a wide distribution from over 600,000 cubic metres per year per person being available for each person in Iceland, to 10,000 in Sweden and Malaysia, to 3000 in France and India, to 250 in Palestine and Saudi Arabia. In fact, most of the Middle East is already classified as being water-scarce according to these definitions, but perhaps more surprisingly so are Malta and Singapore, while Denmark, Poland and the Czech Republic are classed as water-stressed. In total, approximately 290 million people live in countries that are classed as water-scarce, and another 440 million live in countries that are water-stressed.

With the looming prices of food and oil, water scarcity should be on the top global agenda. With the increased global economy the world’s thirst is also increasing. The UN predicts that by 2025, two-thirds of us will experience water shortages, with severe lack of water blighting the lives and livelihoods of 1.8 billion. Furthermore, according to the World Water Assessment Programme, by 2050, 7 billion people in 60 countries may have to cope with water scarcity. The Earth's atmosphere contains approximately 13,000 km^3 of water. The total usable freshwater supply for ecosystems and humans is about 200 000 km3 of water. This represents less than 1 percent of all (35 million km^3) freshwater resources.

We, therefore, desperately need a global joined-up thinking by leaders to secure future water supplies and to rethink how we use water. The problem is especially obvious when we consider the rapid growing human population and the global warming which is likely to result in unpredictable patterns of rainfall and drought.

2. Water, Agriculture and Food Security

Water for irrigation and food production constitutes one of the greatest pressures on freshwater resources. Agriculture accounts for around 70 percent of global freshwater withdrawals, even up to 90 percent in some fast-growing economies. Irrigation increases most crop yields by 100 to 400 percent, and irrigated agriculture currently contributes to 40 percent of the world's food production on 20 percent of the cultivated land.

It is predicted that climate change that yields from rain-dependent agriculture could be down by 50 percent by 2020. In addition, due to climate change, Himalayan snow and ice, which provide vast amounts of water for agriculture in Asia, are expected to decline by 20 percent by 2030. Poor drainage and irrigation practices have led to water logging and salinization of approximately 10 percent of the world's irrigated lands.

"Around 290 million people live in countries that are classed as water-scarce, and another 440 million live in countries that are water-stressed. According to the World Water Assessment Programme, by 2050, 7 billion people in 60 countries may have to cope with water scarcity"

The main challenge facing the agricultural sector is not as much growing 70% more food in 40 years time (when projected population growth is between 2 to 3 billion people), but making 70% more food available on the plate. Future global agricultural water consumption (including both rain fed and irrigated agriculture) is expected to increase by 19 percent (to 8,515 km3 per year) by 2050 **(Figs. 3a & 3b)**.

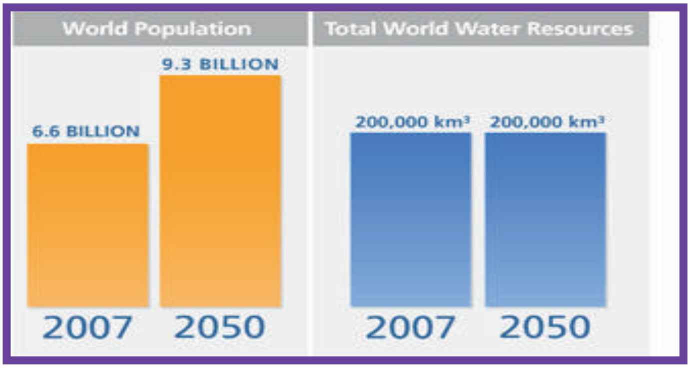


Fig. 3a. World population will increase by at least 3 billion people in the four decades, but, the amount of freshwater available remains the same**.**

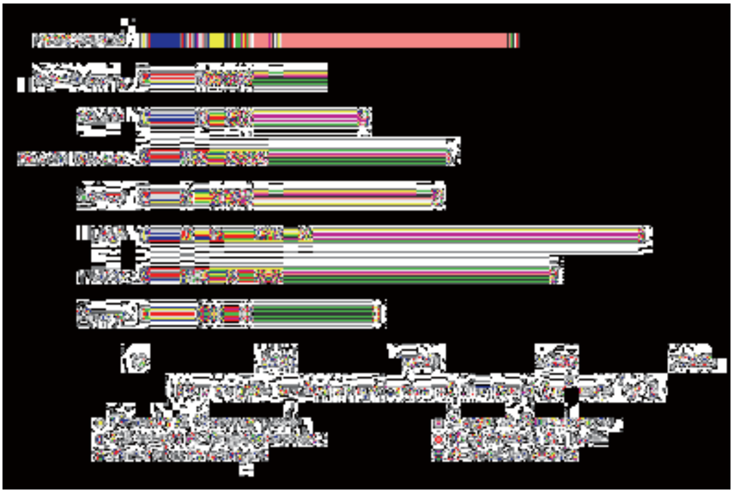


Fig. 3b. Per capita water requirement for food (CWRF) at the cultural level in 2003 in different regions. CWRF in all regions is estimated with virtual water content of individual food items determined on the basis of China's specific production conditions. (Adapted from Lui & Savenije, 2008)

In addition the shift in diets from starch-based food to meat and dairy products will have the greatest impact on water consumption and will continue well into the middle of the 21st century. For instance, the daily drinking water requirement per person is 2-4 liters, but it takes 2,000 to 5,000 liters to produce a person's daily food. Also, it takes about 1,500 liters to produce 1kg of grain while 15,000 liters are required to produce 1kg of beef. It is expected that meat consumption is expected to rise from 37 kg per person per year in 1999/2001 to 52 kg in 2050 (from 27 to 44 kg in developing countries), implying that much of the additional crop production will be used as feed for livestock production. This will have a significant further impact on water use that is already stressed.

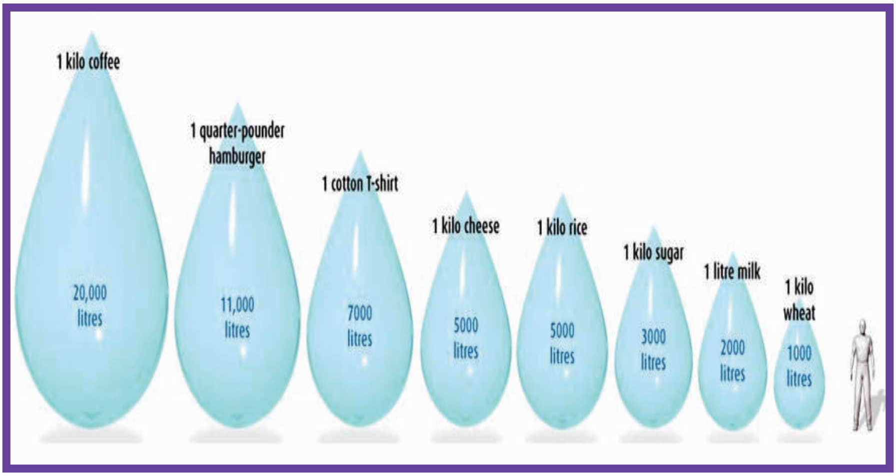


Fig. 4. Amount of fresh water required to produce some products for human needs

Dietary shift in China, the country that is home to one-fifth of the world's population, from cereal to animal products (particularly meat) resulted in a significant increase in water needed for food per capita **(Fig. 5).** In China in 1961, the per capita per year amount of water required for food was 255 cubic meters and currently it is about 860 cubic meters. If other major countries follow the same pattern it will further increase pressure on freshwater demands. At the same time, China's biggest need is to reduce water used for growing food. Two-thirds of the country's water supplies is used by farms. About 1200 cubic kilometers of water is pumped from rivers and aquifers to irrigate Chinese fields each year. With rivers run dry and fields turn to dust, no wonder that China has announced dramatic plans to cut water use by its industry and agriculture. Also, the rapid decline in China's agriculture is prompting fears that the country may not be able to feed itself.

Agriculture accounts for around 70 % of global freshwater withdrawals, even up to 90 % in some fast-growing economies"

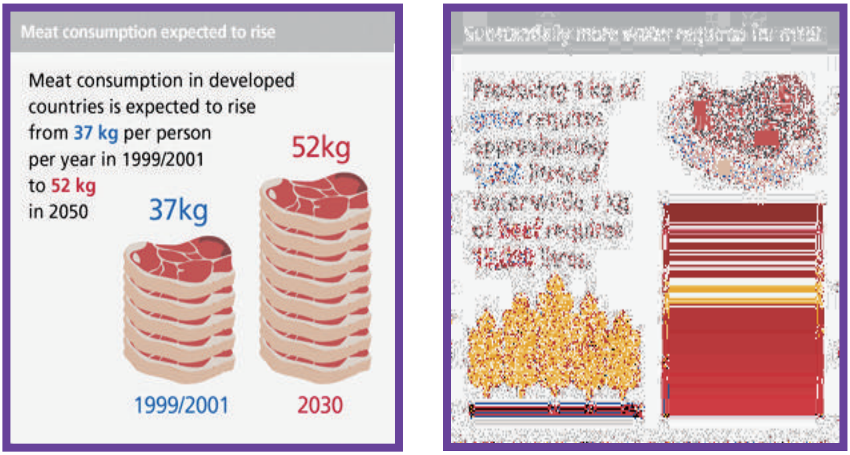


Fig. 5. Future increase in meat consumption will impact on the amount of water

Chinese farmers are abandoning the millennia-old tradition of growing rice in favour of fruit and vegetables. This is having a profound effect and harmful effect on the quality of China's soil and water. The change in Chinese farming resulted in the change of millions of hectares to growing fruits and vegetables. After just five years, fields growing fruit and vegetables are becoming more acidic and infertile, while nitrate and phosphate levels and fungal infections of plants are rising sharply. Fields where such crops are grown are becoming more acidic falling from 6.3 to 5.4 within a decade.

The changes in soil chemistry have been accompanied by an equally dramatic decline in soil bacteria and fungal diseases in plants. Anything that disrupts microbial activity and function in soil could be expected to affect long-term soil productivity, and have serious consequences. The deterioration is worst when the crops are grown under plastic. These changes are affecting vegetable yields and quality and various plant diseases are not easy to control by the usual pesticides. Another obvious concern would be the possible groundwater and well drinking water pollution by leached nitrates and phosphates. Already, a third of the national well water exceeds government norms for nitrate.

It is worth noting that some agronomists suggest that changes in soil chemistry are not being caused by growing fruit and vegetables, but by farmers are applying too much fertiliser to them. It has been documented that while China harvests a similar amount of the crops to the US, it uses almost twice as much fertiliser.

The area of land in China dedicated to grain crops has fallen by 15 per cent since 1998. Chinese officials confirmed that grain yields have fallen and consumption is expected to exceed production by millions of tonnes. This demand for imported grain has triggered a 30 per cent rise in global grain prices in 2004, and further rises are expected as Chinese demand soars. The root problem is that China is urbanising fast. Already 500 million Chinese live in towns and cities, and is likely to rise to 800 million by 2020. Cities are spreading across former farmland and are getting first call on scarce water resources.

Furthermore, increased water shortages in China is caused by industrial pollution, which is making river water unfit for drinking even after treatment. China's urban supply systems and irrigation networks are falling short by about 40 cubic kilometers of water a year. The southern part of China is rich in freshwater while the northern part is arid. Plans to divert water from the southern to the northern regions are very expensive and are estimated to cost in excess of $60 billion.

3. Meat water needs

Recent studies concluded that meat is murder on the environment. It can inflict damages and significantly contribute to global warming, water acidification and eutrophication, and energy consumption. The main culprits are calf production, animal management and the effects of producing and transporting feed. The combined effect of these effects can assist in estimating the impact of a load of beef can have on the environment.

One kilogram of beef leads to the emission of greenhouse gases with a warming potential equivalent to 36.4 kilograms of carbon dioxide. It also releases fertilising compounds equivalent to 340 grams of sulphur dioxide and 59 grams of phosphate, and consumes 169 megajoules of energy. In other words, a kilogram of beef is responsible for the equivalent of the amount of CO_2 emitted by the average European car every 250 kilometres, and burns enough energy to light a 100-watt bulb for nearly 20 days.

"Agriculture accounts for around 70 % of global freshwater withdrawals, even up to 90 % in some fast-growing economies"

Most of the greenhouse gas emissions are in the form of methane released from the animals' digestive systems. Methane is a powerful greenhouse gas. Recent animal feeding practices lead to a decline in methane emissions from beef cattle. Acid and fertilising substances come primarily from the animals’ waste. Over two-thirds of the energy goes towards producing and transporting the animals' feed.

Possible interventions include better waste management and shortening the interval between calving by one month. This latter measure could reduce the total environmental load by nearly 6 per cent. A Swedish study in 2003 suggested that organic beef, raised on grass rather than concentrated feed, emits 40 per cent less greenhouse gases and consumes 85 percent less energy.

It is of no surprise that recent studies estimated that cutting back on beef burgers and bacon could wipe $20 trillion from the cost of fighting climate change. The calculations show that reducing individual meat intake to 70 grams of beef or pork a week (a quarter-pounder is

113 grams) would create a carbon sink in the form of 15 million square kilometres of abandoned farmland. Greenhouse gas emissions would also fall by 10 per cent due to the drop in livestock.

Some scientists have suggested voluntary meatless (means no red meat, pork or poultry) day of the week to reduce the consumption of beef. The average US citizen is "eating" 800 kilos of grain per year compared with 250 kilos in China. The US grain, however, is for feeding animals, mainly beef, where 1 kilo of beef takes around 7 kilos of grain to produce.

Apart from the environmental impact production of meat can have, it can also have negative effect on the human health. No matter how lean the cut of meat you still take in saturated fat, and the saturated fat content of the American diet is much, much higher than it should be. The meat industry always advertised for years it is breeding leaner cattle. But, when it talks about lean cuts of meat, it doesn't acknowledge the vast quantities of beef consumed that is in the form of hamburger. The latter typically has about 50 per cent fat.

Further, more than 8 billion chickens and turkeys are killed every year in the USA. The birds' feed contains antibiotics and arsenic, which is used as a biocide. And the arsenic ends up in chicken excrement. That is put back on the fields to grow soybeans and the corn to feed the chickens, but in such quantities that the arsenic is now leaching into the surface water in certain areas. Also, exposure to low levels of antibiotics may result in the emergence of antibiotic-resistant bacteria.

"Poor drainage and irrigation practices led to water logging and salinization of about 10 percent of the world's irrigated lands"

To try and advertise a meatless day in the USA, for instance, is going to be an enormous task. Food and beverage industry is very powerful. Around $34 billion a year is spent by the food and beverage industry on marketing to the American population. By contrast, the social marketing budget of the National Cancer Institute for its big Five-a-Day campaign, promoting five servings of fruit and vegetables a day, was $2 million.

Huge numbers of animals are killed every year in the USA. Currently, the country's population is 286 million and the Americans kill and consume 9 billion animals a year. These include about 35 million head of cattle, 100 million hogs and 8 billion chickens and turkeys. In terms of total meat consumption, the average American male consumes twice what the US Department of Agriculture recommends, and the average American woman consumes about 1.6 times. These values are way above even the high meat-eating countries of Europe.

4. Food Waste and its Impact on Freshwater

By the end of this century, there could be an extra three billion mouths to feed in a time when eating habits are changing significantly putting further burden on water resources and, hence, raising the alarm for a global efforts to evade possible future catastrophes.

Such projections present mankind with wide-ranging social, economic, environmental and political issues that need to be addressed today to ensure a sustainable future for all. One key issue is how to produce more food in a world of finite resources.

Today, we produce about four billion metric tonnes of food per year. Yet due to poor practices in harvesting, storage and transportation, as well as market and consumer wastage, it is estimated that 30–50% (or 1.2–2 billion tonnes) of all food produced never reaches a human stomach. Furthermore, this figure does not reflect the fact that large amounts of land, energy, fertilisers and water have also been lost in the production of foodstuffs which simply end up as waste. This level of wastage is a tragedy that cannot continue if we are to succeed in the challenge of sustainably meeting our future food demands.

Food is number one cause of water use. We always think about turning off the tap while brushing our teeth and take short showers to save water and save the environment. Today, some countries waste almost twice as much water by throwing away food than they use at home every day. In the United States of America, the food wasted contains more energy than is extracted every year from the nation's oil and gas reserves.

Greenhouse gas emissions have been widely discussed. However, the water used to produce food and drink had little attention until recently. There is a growing concern over the availability of water in the UK and abroad in addition to security of supply of food. Therefore, it is vital to understand the connections between food waste, water and climate change.

In 2008 and 2009 reports identified that UK households throw away 8.3 million tonnes of food and drink waste every year, 60% of which (5.3 million tonnes) could have been eaten. By discarding that food, the water and energy that was used to grow and process those foods is not recovered, giving off greenhouse gas emissions that could have been avoided and hence reduce environmental stresses. The report also goes on to identify the countries of origin for wasted food and looks at the context of water scarcity in those regions in the shape of case studies.

Currently, the water and carbon footprint of wasted household food has recently been identified. It highlighted the major environmental consequences of food waste both in this country and globally. Water used to produce food that householders waste represents 6% of the UK's water requirements. This is equivalent to 6.2 billion cubic metres per year.

"It takes about 1,500 liters to produce 1kg of grain while 15,000 liters are required to produce 1kg of beef"

The 6.2 billion cubic metres of water used to produce the 5.3 million tonnes of food that householders waste every year is nearly twice the annual household water usage of the UK. The same wasted food also represents 3% of the UK's domestic greenhouse gas emissions (14 million tonnes of $CO2$ equivalent) with further emissions arising abroad (6 million tonnes of $CO2$ equivalent). In total, these greenhouse gas emissions are the same as those created by 7 million cars each year. Interestingly, for comparison, the current UK household recycling is estimated to save more than 18 million tonnes of C02 per year. This is equivalent to taking 5 million cars off the road.

Through appropriate agencies, work with retailers, food and drink manufacturers and local authorities, 670,000 tonnes of food waste were prevented between 2005 and 2009. That means 670 billion litres of water were saved that otherwise would have been wasted with food. But, there's still more to do.

The figures published, so far, are astonishing and require urgent steps and decision-making to prevent food waste and save money and the environment. The estimated 280 litres of water per day lost through food waste is almost twice the daily average household water use in the UK which is approximately 150 litres per person per day. Furthermore, the greenhouse gases emitted as a result of food wasted, is greater than that saved by the UK households recycling activities.

In the UK the water footprint refers to the amount of water used to produce goods and services consumed in the UK as the sum of direct (e.g. household water) and indirect (e.g. water used along the supply chains of goods and services) use. Carbon footprint refers to the greenhouse gas emissions of a product across its lifecycle, from raw materials through production or service provision, distribution, consumer use and disposal/recycling.

Avoidable food waste is classified as food which is thrown away that was, at some point, edible. It is usually thrown away due to cooking, preparing or serving too much or because it was not used in time. World communities should have a vision of having a world without waste, where resources are used sustainably. All hand in hand to find solutions to our serious environmental issues so that Man and nature can thrive. Global collective efforts are needed to overcome world water – food – energy – and environment problems.

Food wastage is typical of countries that have an abundance of food. Per capita food waste by consumers in Europe and North-America is estimated at 95-115 kg/year, while this figure in Sub-Saharan Africa and South/Southeast Asia is only 6-11 kg/year. A 50% reduction of food losses and waste at the global level would save 1,350 cubic kilometres of water (for comparison, the mean annual rainfall over Spain is 350 km3; water passing Bonn in Die Rhine is around 60 km3 per year; the storage capacity of Lake Nasser nearly 85 km3)

"Organic beef, raised on grass rather than concentrated feed, emits 40 % less greenhouse gases and consumes 85 % less energy"

Grocery waste in manufacturers and retailers amounts to 6.5 Mt. Some 4.9 Mt arises in manufacturing and some 1.6 Mt arises in retailing. The waste comprises 4.3 Mt of food, 1.6 Mt of packaging and 0.5 Mt ‘other’ material.

4.1.Where food is wasted

There are three principal emerging population groups across the world, based on characteristics associated with their current and projected stage of economic development. First, there are the fully developed, mature, post-industrial societies, such as those in Europe. Such societies are characterised by stable or declining populations which are increasing in age. Second, late-stage developing nations that are currently industrialising rapidly, for example China, which will experience decelerating rates of population growth, coupled with increasing affluence and age profile. Last, but not least, newly developing countries that are beginning to industrialise, primarily in Africa, with high to very high population growth rates (typically doubling or tripling their populations by 2050), and are characterised by a predominantly young age profile.

Overall, each group over the coming decades will need to address different issues surrounding food production, storage and transportation, as well as consumer expectations, if we are to continue to feed all our people. Food waste varies from one group to another.

Food waste in less-developed countries, such as those of sub-Saharan Africa and South-East Asia, tends to take place primarily at the farmer-producer end of the supply chain. Inefficient harvesting, inadequate local transportation and poor infrastructure mean that crops are frequently handled inappropriately and stored under unsuitable farm site conditions.

In contrast, fully developed countries, such as the UK, there is more-efficient farming practices and better transport, storage and processing facilities. These facilities ensure that larger proportion of the food produced reach markets and consumers. On the other hand, majority of food waste is due to consumer culture and retail behaviour.

For instance, to meet consumer expectations, major supermarkets will often reject entire crops of perfectly edible fruit and vegetables at the farm because they do not meet exacting marketing standards for their physical characteristics, such as size and appearance. For example, up to 30% of the UK's vegetable crop is never harvested as a result of such practices. Globally, retailers generate 1.6 million tonnes of food waste annually in this way.

Of the produce that does appear in the supermarket, commonly used sales promotions frequently encourage customers to purchase excessive quantities which, in the case of perishable foodstuffs, inevitably generate wastage in the home. Overall between 30% and

50% of what has been bought in developed countries is thrown away by the purchaser. In the UK, over-conservative sell-by dates on labels and two-for-one offers of perishable items are key factors, encouraging consumers to buy too much food to start with and to throw away items that have reached their sell-by date, but which are still edible. The problem is that the sell-by dates are selected not to protect the consumer from rotten food, but to give supermarkets huge safety margins. This in turn minimises any risk of consumers eating their products, getting ill and then suing them.

It is urgent that we implement better uses of our finite resources. By wasting food we are not only losing the sole life-supporting nutrition but also adversely affecting our precious resources, including land, water and energy. As a global society, therefore, tackling food waste will help contribute towards addressing a number of key resource issues:

4.2.Proper management of land, water and energy uses

Improved technologies, techniques and knowledge in farming had a significant impact on increasing crop yields and resulted in the expansion of farm land use. However, with global food production already utilising about 4.9Gha of the 10Gha usable land surface available, a further increase in farming area without impacting unfavourably on what remains of the world's natural ecosystems appears unlikely.

The challenge is that an increase in animal-based production will require greater land and resource requirement, as livestock farming demands extensive land use. One hectare of land can, for example, produce rice or potatoes for 19–22 people per annum. The same area will produce enough lamb or beef for only one or two people. Considerable tensions are likely to emerge, as the need for food competes with demands for ecosystem preservation and biomass production as a renewable energy source.

"Greenhouse gas emissions as a result of food wasted in the UK are the same as those created by 7 million cars each year"

In the past few decades, human use of freshwater has increased at more than double the rate of population growth. Currently, about 3.8 trillion cubic metres of water is used by humans per annum. About 70% of this is consumed by the global agriculture sector, and the level of use will continue to rise over the coming decades particularly with increased world population. Also, in the next 50 years or so, demand for water in the food production could reach 10–13 trillion cubic metres per year.

About 40% of the world's food supply is currently derived from irrigated land. Therefore, improved irrigation systems can dramatically increase crop yield. However, water used in irrigation is often sourced unsustainably. In addition, many countries continue to use flood or overhead spray methods of irrigation. These tend to be wasteful systems which are difficult to control and lose much of the water through evaporation. Nevertheless, other approaches such as the drip or trickle irrigation methods can be as much as 33% more efficient and can carry fertilizers directly to the roots of plants. Although these systems are expensive, they are cost-effective in the long run through increased crop yields.

Another area of attention regarding management of water use is the processing of foods after the agricultural stage. This is particularly crucial in the case of meat production, where beef uses about 50 times more water than vegetables. In the future, more effective washing techniques, management procedures, and recycling and purification of water will be needed to reduce wastage.

4.3.Energy Usage

It is well established that water and energy are closely interlinked and interdependent. Energy generation and transmission requires utilisation of water resources, particularly for hydro electric, nuclear, and thermal energy sources. Recent interest in biofuels also creates an incremental demand on water resources; the latest World Water Development Report (2012) predicts that even a nominal increase in biofuel demand (say 5% of road transport by 2030, as predicted by International Energy Agency) could push up the water demand by as much as 20% of the water used for agriculture worldwide. Additionally, biofuel production is linked to increases in water pollution through increased use of fertilisers and agricultural chemicals. Conversely, about 8% of the global energy generation is used for pumping, treating and transporting water to various consumers. Co-production of water and energy, as is the case for geothermal energy generation, offers interesting opportunities to energy- and water-scarce countries.

The UN system, working closely with its Member States and other relevant stakeholders, are collectively bringing attention to the water-energy nexus, particularly addressing inequities, especially for the 'bottom billion' who live in slums and impoverished rural areas and survive without access to safe drinking water, adequate sanitation, sufficient food and energy services.

It also aims to facilitate the development of policies and crosscutting frameworks that bridge ministries and sectors, leading the way to energy security and sustainable water use in a green economy. Particular attention is being paid to identifying best practices that can make a water- and energy-efficient 'Green Industry' a reality; several methodologies are at play in which industrial productivity can be increased while reducing the water footprint.

Across the entire food production cycle, energy is an essential mean. It is estimated that an average of 7–10 calories of energy input is required produce one calorie of food. This varies dramatically depending on crop, from 3 calories for plant crops to 35 calories in the production of beef. Since much of this energy comes from the utilisation of fossil fuels, wastage of food potentially contributes to unnecessary global warming as well as inefficient resource utilisation.

"The UK households throw away 8.3 million tonnes of food and drink every year, 60% of which could have been eaten"

Agrochemicals such as fertilizers and pesticides represent the biggest energy input into the making and application of these two items. These are needed by developing nations to implement in modern agricultural processes to increase future yields. For instance, wheat production takes 50% of its energy input from these two items alone. On a global scale, fertiliser manufacturing consumes about 3–5% of the world's annual natural gas supply. With production anticipated to increase by 25% between now and 2030, sustainable energy sourcing will become an increasingly major issue. Energy to power machinery, both on the farm and in the storage and processing facilities, together with the direct use of fuel in field mechanisation and produce transportation, adds to the energy total, which currently represents about 3.1% of annual global energy consumption.

Expected rise in global population combined with improved nutrition standards and shifting dietary preferences will undoubtedly exert pressure for increases in global food supply. Experts including engineers, scientists and agriculturalists have the means to assist in achieving productivity increases. However, pressure will grow on the finite resources of land, energy and water. However, by simply eliminating food losses, you will ensure a significant amount of food getting to the consumer and will simultaneously free land, energy and water resources for other uses.

In order to begin tackling the challenge, it is recommended that the international community in the developed nations assist newly developing countries in increasing their food yields. This can be achieved by transferring knowledge, design know-how and suitable technology to developing nations. This will help improve produce handling in the harvest, and immediate post-harvest stages of food production. Authorities in rapidly developing countries could incorporate facilities into their planned infrastructure to minimise food wastage. Partly this could be achieved by establishing appropriate transportation and storage facilities.

Because of the enormity of food wasted in the developed countries, implementation of policies to change consumer's behaviour and expectations are badly needed. This should discourage retailers from wasteful practices that lead to the rejection of food on the basis of cosmetic characteristics. It will also discourage excessive purchasing by consumers and hence reduce food waste at home.

5. "Virtual Water"

Virtual water is the water used to grow or rear livestock that is then exported. When the US or the UK imports Argentinean beef or Spanish oranges, respectively, large amounts of water are imported with them. It has been estimated that 62% of the water used each year in the UK is virtual. This is what may also be referred to as the "unseen water trade". If a certain country imports one ton of wheat instead of producing it domestically, it is saving about 1,300 cubic meters of real indigenous water. If this country is water-scarce, the water that is 'saved' can be used towards other ends. If the exporting country is water-scarce, however, it has exported 1,300 cubic meters of virtual water since the real water used to grow the wheat will no longer be available for other purposes. This has obvious strategic implications for countries that are water-constrained such as those found in the Southern African Development Community area.

"The 6.2 billion m^3 of water used to produce the 5.3 million tonnes of food that householders waste every year is nearly twice the annual household water usage of the UK"

It has emerged that some of the world's least developed countries now participate in the global food trade, breaking the link between local water resources and food security. Figures from the FAO show that in 2002, imports made up a fifth of the grain supply across sub-Saharan Africa, the region with the lowest average national incomes in the world, with food aid making up less than a fifth of the total food imports in least developed countries. Since the 1960s the world's least developed countries have changed from being net exporters to being significant net importers of agricultural commodities, and hence have become major importers of virtual water, even though most are not particularly short of water.

China, India and Saudi Arabia have lately leased vast tracts of land in sub-Saharan Africa at knockdown prices. Their primary aim is to grow food abroad using the water that African countries don't have the infrastructure to exploit. Doing so is cheaper and easier than using water resources back home.

Between 2004 and 2009, Saudi Arabia leased 376,000 hectares of land in the Sudan to grow wheat and rice. At the same time the country cut back on wheat production on home soil, which is irrigated with water from aquifers that are no longer replenished i.e. a finite resource.

Also, firms from China and India have leased hundreds of thousands of hectares of farmland in Ethiopia. Both China and India have well-developed irrigation systems. In China, for example, moving water from the water-rich south to northern China, is likely to be more costly than leasing land in Africa, making the land-grab a tempting option. Such plan was estimated to cost more $50 billion.

But why bother leasing land instead of simply importing food? Such imports are equivalent to importing "virtual water", since food production accounts for nearly 80 per cent of annual freshwater usage.

Of course, trade in virtual water does not reduce overall demand for water but rather shifts it from one place to another. However, with such a growing trade in virtual water, it no longer makes sense to use self-sufficiency in food production to define water scarcity. As with so many other commodities that are traded globally, self-sufficiency in food production is not a requirement for individual countries so long as water resources remain adequate at the global level, in the same way that so many countries are heavily dependent on the global oil trade, without which their economies would grind to a halt.

Globally, there is adequate fresh water available, and that looks set to continue in the long term. Figures from the FAO indicate that we currently extract less than 10 per cent of the 43,750 cubic kilometres of fresh water returned each year to the Earth's rivers, lakes and aquifers. The water is not distributed evenly, of course. Within a given country water consumption can vary from less than 1 per cent of available resources to more than 100 per cent, meaning that in some cases resources are being overexploited and degraded. Nevertheless, countries such as France, Germany, Italy and Spain have all shown that it is possible to extract 20 per cent or more of renewable water resources a year while maintaining acceptable environmental quality. Globally we are still some way from hitting any real environmental ceiling on consumption, and the growing trade in virtual water means that scarcity in one region can be compensated for by increased production in places with more plentiful supplies.

"About 7–10 calories of energy input is required to produce 1 calorie of food; around 3 calories are needed for every calorie in plant crops compared to 35 calories required for each nutritional calorie of beef"

Knowing the size of a country's fresh water resources does not allow you to predict how developed it is. In many desert states in the Middle East, for example, you will never lack safe drinking water, whereas in many water-rich countries in Africa you will.

So how much water does a country really need remains arguable. However, the lowest estimate was put at just 20 litres per person per day. This figure considers only the amount of water required for drinking, cooking and very basic hygiene. A nation could offer a high quality of life with as little as 135 litres of water per person per day. If 135 litres is the bare minimum that will allow a country to prosper, at present, only Kuwait and the United Arab Emirates fall short of this low-water mark in terms of their naturally available renewable water resources. But, both countries make up their shortfall through desalination, and human development in both of these countries is already classed as high. An average UK citizen consumes about 150 litres of water per day.

Plentiful water is clearly beneficial for national development, and it is imperative that total water resources remain sufficient for global food production. However, the fundamental problem many nations face is not water scarcity but distribution both within countries and between them.

Nevertheless, there are positive signs that we can overcome these problems. According to the WHO and UNICEF, between 1990 and 2002 the percentage of the global population with access to safe drinking water rose from 77 to 83 per cent. Meanwhile, the trade in virtual water continues to grow, shifting agricultural production from areas of water scarcity to those with relative plenty. Governments are also starting to rethink their water management policies - although admittedly these are still often fragmented and contradictory. What's more, with desalination now as cheap as 50 cents per 1000 litres, all but the world least developed countries can afford to supplement their natural supplies of fresh water as long as they have a coastline. Millions are suffering because of a lack of water, but ensuring the supply of 135 litres per person per day is not beyond our reach.

6. Water Quality

Years of global observations together with decades of essential research, scientists are now convinced more than ever that fresh water systems across the planet are in an uncertain state. Also, we should not forget that the health of the oceans is spiraling downwards far more rapidly than we had ever thought. This is resulting in exposing microorganisms to intolerable and unpredictable evolutionary pressures.

The already stressed resource is further affected by global pollution which is negatively affecting the aquatic life forms and the health of human beings. Mismanagement, overuse and climate change pose long-term threats to human well-being. Evaluating and responding to these threats is a major multidisciplinary task involving environmental scientists, social scientists, engineers, policy-makers, and a wide range of stakeholders. Human activities play a major role in the behavior of the global water system and it is widely believed that today's water problems are entirely avoidable. Therefore, a joint global effort is urgently required to avert such universal problem.

"In the next 50 years or so, demand for water in the food production could reach 10–13 trillion m^3 per year"

6.1.The deadly three

It is well established that oceans are warming and acidifying. And very recently it turns out they are suffocating, too. It has been warned that seas will have lost as much as 7 per cent of their oxygen by the end of the century. Low oxygen levels have occurred in previous eras when there was mass extinction. Are we now seeing signs of a repeat? Some scientists on the other hand say such reports are exaggerated. However, there is general agreement that warming of surface seawater, acidification and deoxygenation is real. If we do not reduce CO_2 emissions ocean deserts will carry on expanding leading to reduced fisheries potential in the coming decades.

The ocean's surface has been warming as fast as the atmosphere. Warmer water holds less oxygen creating a floating surface that mixes less with the colder layers below. This leads to the establishment of oxygen-poor deep water that could suffocate life on the seabed.

Seawater is becoming less alkaline. Acidification is resulting from the increased absorption of ever more CO_2 from the atmosphere.

CO_2 levels are rising owing to increased fossil fuel use. As a result, seawater holds less calcium carbonate which essential for corals, molluscs and other creatures to make their own shells. These animals are struggling because of the reduced calcium carbonate. It is expected that, if such cascade of chemical and biological changes continue, coral reefs can be irreversibly destroyed in the 50 to 100 years. Marine ecosystems will then increasingly be taken over by jellyfish and toxic algal blooms.

6.2.Sewage Irrigation

It has been documented that a tenth of the world's irrigated crops are watered by sewage. These crops include soft vegetables and fruits which are consumed raw. Much of that sewage is directed to fields raw and untreated. Such water is very rich in microbes as it is likely to contain human and animal waste. In addition, despite its stinking characteristics, farmers like to use it because it is rich in nitrates and phosphates which make it a free fertiliser for their crops.

Wastewater irrigation is prohibited by authorities in many countries but none of the health and agriculture would to recognise that it is widespread practice. About 20 million hectares of the world's farms are irrigated with sewage. Some suggested that a quarter of Pakistan's vegetables, including salad crops, are grown in sewage effluent. Such business is booming. Farmers in West African cities grow several crops (up to 12) of lettuce a year from their own sewage farm. Furthermore, in many fast-growing megacities, clean water is in desperately short supply, where sewage is plentiful. Ironically, sewage pipes keep flowing even in the dry season, when irrigation canals often dry up.

Farms that hooked up to sewage pipes make big profits. It seems that in parts of Pakistan the price of fields irrigated by sewage pipes is twice that of neighbouring fields irrigated with clean water. It is worth remembering that some countries like Mexico and Tunisia treat their sewage to remove microbes so it is safe for irrigation. However, in some parts in India, China and Pakistan sewage treatment is rare. The total population of these three countries represents almost 40% of the world population 7 billion people. Therefore, such practice may have a catastrophic affect on human health. We should not forget that in addition to disease-causing microbes, toxic industrial waste may also be present. Based on a recent (July 2013) estimate by the UN, Lebanon population represents 0.068 of the total world population.

Sewage is probably the biggest source of water for urban farming, which provides an estimated one fifth of the world's food. Some reported that in Hyderabad (India), pretty much 100 per cent of the crops grown around the city rely on sewage because there is no other water available.

"A tenth of the world's irrigated crops are watered by sewage and about 20 million hectares of the world's farms are irrigated with sewage"

Banning the practice is not usually practicable because we have to admit that sewage is a valuable resource that grows huge amounts of food. So, instead, perhaps we should help the millions of farmers involved to do it better and perhaps focus on making the waste safe for irrigating crops particularly the ones that are consumed uncooked such as soft vegetables and soft fruits.

6.3.Regional Study to Evaluate the Microbiological Quality of Water and Vegetables Commonly Consumed in Lebanon

It is well established that vegetables intake is widely recommended because of its high content of vitamins, minerals and dietary fibers, However the irrigation of these vegetables using wastewater that have received inadequate treatment often carries unseen microbial pollution that becomes a high risk potential for humans.

We have carried out a study that was designed and aimed at assessing the microbiological quality of fresh vegetables including lettuce, parsley and *Malva* samples collected from several regions in

Bekaa Valley area. These vegetables were irrigated using Litani river water. Water samples from the river were also collected and the microbiological quality of which was assessed.

It is assumed that if an organism like *Escherichia coli* is present in food or water samples it an indication of faecal contamination and, therefore, potentially pathogenic organisms are present. So, another aim of this study was to evaluate the status of *E. coli* in the vegetables samples collected in addition to its presence or absence in Litani river water. As a control, water samples from ground water were evaluated for its microbiological quality.

6.3.1. Fruit and Vegetable Contamination

Globally, vegetables have been associated with outbreaks of foodborne disease in many Countries. Organisms involved include bacteria, viruses and parasites. These outbreaks vary in size from a few persons affected to many thousands. However, they represent only a small proportion of the total number of cases reported. For example, in the US between 1993 and 1997 vegetables were associated with only 1.4% to 3% of all outbreaks. However, the Centers for Disease Control and Prevention reported that the number of produce-associated outbreaks per year in the US doubled between the periods 1973-1987 and 1988-1992. It is worth mentioning that, today, in the USA there are more than 75 million cases of water and foodborne diseases.

The world's largest reported vegetable borne outbreak to date occurred in Japan in 1996 when more than 11,000 people were affected. The outbreak was caused by *E. coli* O_{157}:H_7 and was responsible for the death of three school children and. The organism was also responsible for the recent scare in Europe when it caused an outbreak in cucumber in Germany and then spread fast to many countries.

"Sewage is probably the biggest source of water for urban farming, which provides an estimated one fifth of the world's food"

This organism is one of the emerging organisms and that was first identified in the early 80s. This new type of *E. coli* is of great interest because it can cause serious diseases in humans, particularly in children and elderly people. It can cause a wide range of illnesses ranging from bloody diarrhea to possible kidney failure and brain clots and death. The main reservoir of the organism is cattle. That is why unpasteurized milk and improperly cooked beef burgers are common vehicles for the transmission of the bacterium. Vegetables irrigated by water contaminated by this organism can lead to contamination of vegetables particularly those which are consumed uncooked.

Perhaps one of the most important characteristic of this organism is that the infective is between 10 and 100 organisms which is one of the lowest levels ever recorded for bacteria. For comparison, the tip of the needle can accommodate approximately 1 million organisms. Because of its low infective dose, person-to-person transmission is also possible. In addition, infection can also be contracted by just swimming in water contaminated by the organism.

Numerous surveys have been carried out in many countries to determine the presence of pathogenic microorganisms on raw fruits and vegetables. In many instances, bacterial pathogens have not been detected. In other investigations, high percentages of samples have been found to contain bacteria capable of causing human disease. Several outbreaks were caused by bacteria, viruses and parasites and have been linked epidemiologically to consumption of raw fruits and vegetables.

Increased recognition of raw fruits and vegetables as suspected vehicles of human illness in industrialized countries may probably result in increased numbers of associated or confirmed cases in the future. Other factors, however, may contribute to real increases in diseases associated with fruits and vegetables. These include use of wastewater, increased application of improperly composted manures to soils in which fruits and vegetables are grown, changes in packaging technology such as the use of modified or controlled atmosphere and vacuum packaging, extended time between harvesting and consumption, and changing food consumption patterns (e.g. eating more meals away from home, including greater use of salad bars).

Raw and minimally-processed fruits and vegetables are an essential part of people's diet all around the world. Where land is available, families grow fruits and vegetables for their own use. Alternatively, produce is purchased from local farmers or retail outlets for further preparation by street vendors, by families at home or as part of meals eaten in restaurants and other food-service facilities. While advances in agronomic practices, processing, preservation, distribution and marketing have enabled the raw fruit and vegetable industry to supply high-quality produce to many consumers all year round, some of these same practices have also expanded the geographical distribution and incidence of human illness associated with an increasing number of pathogenic bacterial, viral and parasitic microorganisms.

Concerns about pathogens in vegetables has risen because of the increasing numbers of outbreaks of food-borne illnesses caused by the consumption of fresh, whole, cut and minimally processed vegetables. A few outbreaks associated with the consumption of conventionally grown lettuce contaminated with pathogens such as *E.coli* O_{157}:H_7 and *Salmonella spp* have been reported.

Fresh fruits and vegetables continue to be a public health concern from the standpoint of food safety. In the last several decades, the proportion of foodborne disease outbreaks in the United States of America associated produce rose from 0.7% of outbreaks in the 1970s to 6% of outbreaks in the 1990s. Likewise, produce associated outbreaks in the USA were responsible for a higher proportion of all foodborne disease cases from 1% (708 of 68,712) of cases in the 1970s to up to 12% (8,808 of 74,592) of cases in the 1990s.

The frequency of produce-associated outbreaks in Europe appears to be similar to that in the United States. Between 1992 and 1999, 60 outbreaks of foodborne infectious intestinal disease were associated with the consumption of salad items. Vegetable-associated outbreaks represent 4.3% of the total number of outbreaks of foodborne disease reported during that period. Also, vegetables contamination was reported from England and Wales.

"Water used to produce food that householders waste represents 6% of the UK's water requirements"

6.3.2. Microbial ecology of raw vegetables and soft fruits

Microorganisms normally present on the surface of raw fruits and vegetables may consist of chance contaminants from the soil or dust, or bacteria or fungi that have grown and colonized by utilizing nutrients exuded from plant tissues. Among the groups of bacteria commonly found on plant vegetation are those that test positive for coliforms or faecal coliforms, such as *Klebsiella* and *Enterobacter*. In Sweden, salad containing one or more cooked ingredients accounted for 4.3% of the 252 reported incidents of foodborne illness between 1992 and 1997.

Microorganisms capable of causing human illness and others whose foodborne disease potential is uncertain, such as *Aeromonas hydrophila, Citrobacter freundii, Enterobacter cloacae and klebsiella spp* have been isolated in lettuce and salad vegetables. Some reported the presence of *Staphylococcus aureus, Escherichia coli, Enterobacter sp, Klebsiella sp, Providencia sp and Pseudomonas aeruginosa* ($\geq 10^{10}$ CFU g^{-1}) on salad vegetables such as carrots, radishes, tomatoes, lettuce, cabbage, cucumbers and coriander. Moreover, faecal coliforms, *Listeria* and *Yersinia* in fresh leafy vegetables, salad components and ready to eat salads (10^{10}- 10^{8} CFU g^{-1}) were detected. The incidence, growth and survival of pathogens such as *Listeria monocytogenes, Salmonella, Escherichia coli and Clostridium botulinum* has been detected in fresh-cut produce such as carrots, cucumbers, and tomatoes in the USA. However, others reported the presence of *Bacillus cereus, Campylobacter, Escherichia coli, Salmonella, Shigella and Staphylococcus sp*. on salad vegetables such as spinach, cucumbers, coriander, tomatoes, carrots and radish.

The bacteriological quality of salad vegetables had been examined in Amravati city (India) and indicated the presence of *Escherichia coli, Pseudomonas, Staphylococcus aureus, Salmonella and Shigella* in most vegetable samples. However, the bacteriological analysis of fresh produce in Norway in many vegetable samples such as lettuce, parsley, mushrooms which were analyzed for the presence of thermo tolerant coliform bacteria, *Escherichia coli*, *Salmonella sp, Listeria monocytogenes, Staphylococcus sp* and *Yersinia enterocolitica*, but neither *Salmonella sp* nor *Escherichia coli* O_{157} were isolated.

6.3.3. Sources of contamination

The rapid flow of partly digested food through your small intestine makes it a poor home for microbes, since the bugs are constantly being washed through. In the colon, however, things slow down and microbial concentrations soar. Thousands of different types of microbe inhabit the gut, an estimated kilogram's worth in the average adult. Without them we would not be able to digest certain foods, metabolise drugs, detoxify noxious compounds or make essential vitamins.

"The human gut contains more than 1kg of microbes. The enormity of such weight of organisms is evident when we appreciate that a single bacterium weighs about 0.000 000 000 001 grams"

Vegetables can become contaminated with pathogenic microorganisms during harvesting through human handling, harvesting equipments, transport containers, wild and domestic animals. The pathogenic microorganisms which reside in the intestinal tract of humans and animals are more likely to contaminate vegetables through feces, sewage, untreated irrigation water or surface water **(Fig. 6).** The human body, consisting of about 100 trillion cells, carries about 10 times as many microorganisms in the intestines. The metabolic activities performed by these bacteria resemble those of an organ, leading some to liken gut bacteria to a "forgotten" organ. The human gut contains more than 1kg of microbes **(Fig. 7).** The enormity of such weight of organisms is evident when we appreciate that a single bacterium weighs about 0.000 000 000 001 grams. Another 200 grams are distributed on and in the rest of the body parts. It has also been suggested that 1 gram of human faeces may contain up to 10^{13} cells. Therefore, human faces may act as a main source of pathogens. Untreated, or partially treated, sewage may result in the dissemination of diseases through either water and/or food stuffs.

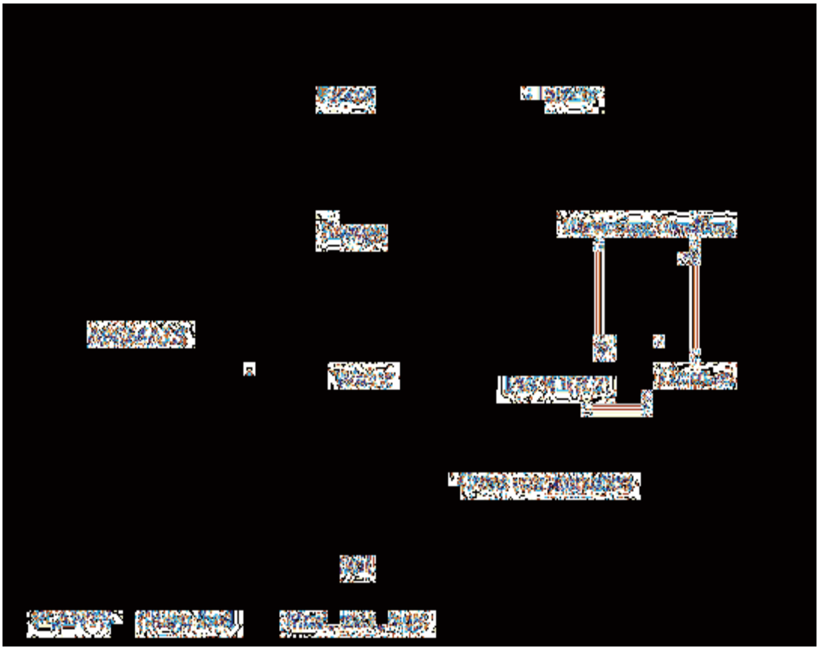


Fig. 6. Mechanisms by which fruits and vegetables may become contaminated with pathogenic microorganisms**.**

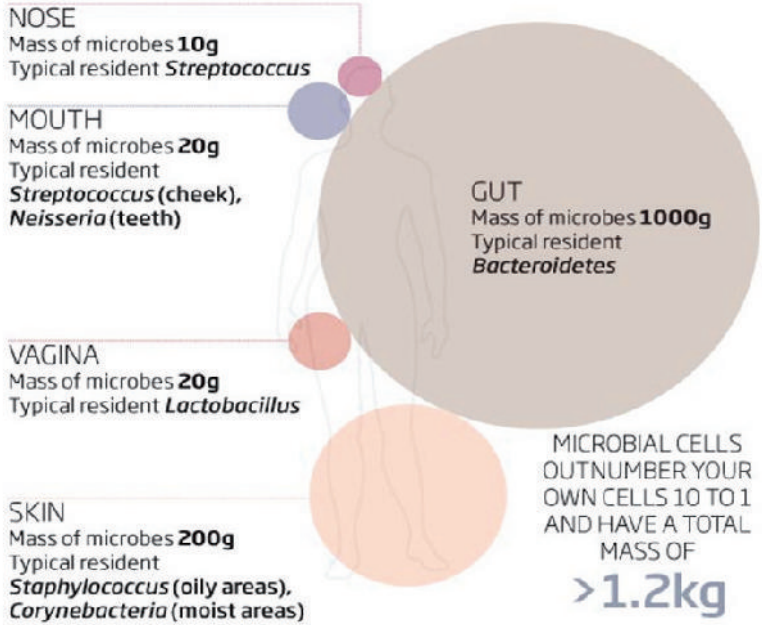


Fig. 7. Distribution of microbes in and on the human body

Contamination of vegetables product may take place at all stages during both pre and post-harvest and processing technique. Unsafe water used for rinsing the vegetables and sprinkling to keep them fresh is another source of contamination. Different authors reported that vegetables are contaminated with microorganisms when they are irrigated with sewage water and when soil is fertilized with manure because both usually contain great amounts of pathogenic organisms. In addition, in Amravati city (India) it had been observed that the local farmers are using municipal wastewater discharged in Ambanala for irrigation and washing purposes which is suspected to be the primary source of contamination of microorganisms in vegetables. Also, it has been shown that vegetables irrigated with untreated wastewater in Morocco had a high level of microbial contamination.

"A 50% reduction of food waste at the global level would save 1,350 km^3 of water (for comparison, the storage capacity of Lake Nasser nearly 85 km3)"

6.3.4. Factors Contributing to contamination of vegetables

6.3.4.1. Growing and Harvesting

Not only insecticides or chemical substances contaminate agricultural produces, but also microorganisms, inhabiting the environment and probably coming from soil, water, and fertilizers pollute vegetables and fruits which are harmful to public health. Several types of microorganisms often found in earth and cause diseases include *Bacillus, Clostridium*, and *Listeria*, especially the ones that can produce highly resistant spores with heat resistance such as *Clostridium botulinum and Clostridium perfringens.* The microorganisms are normally found in the areas for feeding animals.

The microorganisms living in the intestinal tract of animals and being excreted in the excrements may contribute to human diseases. Therefore, using fermented fertilizers for nourishing plants may lead to food contamination by potentially dangerous organisms such as *Salmonella typhimurium and E. coli* O_{157}:H_7 on leaves and roots of vegetables that were nursed by fermented fertilizers.

Furthermore, it was found that *Salmonella, E. coli* O_{157}:H_7 *and Listeria monocytogenes* were able to survive for a long time in the fermented fertilizers. Different types of vegetables and fruits will be contaminated with different amounts and kinds of microorganisms. The quantity of starting microorganisms will indicate the quality of the final products. The presence of large amount of microorganisms will lead to fast deterioration of the quality of vegetables and hence shortening the shelf life of food products and wastage of the product.

6.3.4.2. Initial Stage of Production Process and Transportation

Washing dirt out of the surfaces of vegetables and fruits will help extend the product shelf life because of the reduction of microbial population. Adding antibiotic agents in washing water can increase 100 times the efficiency of eliminating microorganisms on the surface of agricultural produce. The degree of effectiveness in killing germs depends on a mechanism destroying microorganisms by a certain substance, type of microorganism, type of vegetable, and areas in which microorganisms live such as the top of fruit or a deep rut on, for example, an apple which can be cleaned more difficult than the areas with smoother surfaces. Leaf vegetables are most likely to be contaminated because it is easy for microorganisms to hold on a wide surface of the leafy vegetables.

As mentioned earlier, the contamination is usually found on the surfaces of vegetables and fruits because of cells damaged right at the farm by insects, birds or microorganisms. Furthermore, the damage might occur during the harvest. When the production process started, its method might increasingly enhance a contamination, e.g. peeling and cutting into pieces. These activities made plant cells lose their strength; as a result, nutritive contents within the cells leaked out and were utilized for growth and multiplication by microorganisms which were on the plant surfaces.

Proper transport of vegetables is important, and is mostly done by a vehicle with controlled temperature and good ventilation. Therefore, the arrangement of vegetable packages needs to be designed in a way that cold air is allowed to circulate well. Also, vegetables release heat after breathing; therefore, it is important that proper cooling system is capable of dealing with such circumstances. Otherwise, accumulation of warm air may lead to a quick rotting of vegetables.

6.3.4.3.Irrigation Water

Water acts as an excellent medium for growth of microorganisms and it represents one of the major sources of contamination in the production of crops. Contaminated water may affect foods during growth and post-harvesting, irrigation, washing of the product, hydro-cooling, icing, fertilizer and pesticide application, preparation of soil amendments, and equipment and facility washing.

"Around 54.3% of all cultivated fields are irrigated from surface-water sources and 45.7%, from groundwater sources"

Quality and safety of irrigation water used on the farm determines the quality and safety of the produced crop which depends on the water source. Human pathogens can be introduced into irrigation water through run-off of manure from animal production facilities or domestic/urban sewage systems or directly from wildlife. Extreme rainfall, spills of manure, or human waste can increase the probability of contamination occurring, where the main sources of water for irrigation in Lebanon are the Litani and Awali river systems and subsurface water. According to the most recent data, 54.3% of all cultivated fields are irrigated from surface-water sources and 45.7%, from groundwater sources.

Ponds, creeks, and rivers can easily be contaminated due to runoffs containing livestock or wildlife feces, manure or faulty septic systems, and livestock or wildlife entry. Surface water also has more variable microbial quality and the level of contamination may rapidly change. In a settling pond, large particles containing microorganisms will settle at the bottom and the quality of water in ponds depends on the original source and on how well the pond is protected from contamination from runoff and wildlife entry. Special precaution should be taken after heavy rainfalls when surface water may contain sediment and high microbial contamination loads washed in by rainfall. Rainwater storage tanks may be contaminated by bird and rodent feces or dead animals. Recycled municipal waste water if not properly treated presents a high risk of contamination.

Irrigation with untreated wastewater represents an important route for transmission of pathogenic organisms to man. Raw vegetables were considered by some to represent an increased risk to public health when irrigation methods use untreated wastewater and no chemical treatments are employed to reduce the microbiological load on the raw product.

To prevent contamination of crops, it is important to be aware of microbial quality of water. Water should be tested periodically for the presence of microorganisms that are indicators of fecal contamination. The frequency of testing will depend on the nature and extent of contamination. Critical limits for presence of coliforms and *E. coli* will depend on the intended use of the water and the time to harvest. Another important step in water management is to become familiar with the potential sources of microbial contamination of each source of irrigation water used. Factors that affect the risk of contamination from irrigation water are methods of application, time of application in relation to harvest date, and the type of vegetables grown.

Cities in developing countries, including Ghana, are experiencing unparalleled population growth where the rapidly increasing water supply and sanitation coverage generates large volumes of wastewater, which is often released untreated into the environment (streams, drains, etc.). In Ghana, most urban centres have no means of treating wastewater and the sewerage network serves only 4.5 percent of the total population. It was stated that the need for year-round production of vegetables in or near urban areas makes irrigation necessary; hence, farmers are in search of water for irrigation often rely on wastewater. However, despite its importance for countless livelihoods, the use of urban wastewater for irrigation is not without health risks. Wastewater contains the full spectrum of pathogens found in the urban population, many of which can survive for several weeks when discharged onto fields.

Ground water is less likely to be contaminated due to the natural filtration through soil layers. Well water when used directly harbor a relatively low risk of contamination, provided that well walls are properly constructed and well maintained. Still, there is a potential for contamination if animals frequent the area surrounding the wellhead or sewage leaks into the recharge area or as a result of surface water that runs into it especially during rainy season. In Nigeria, 58.33% of water samples collected from the wells contained *E. coli* which, of course, indicates faecal contamination. To prevent runoff from getting into the well and contaminating the water, it is important to maintain the well casing and ensure that it is free of cracks and openings. If well walls are fortified with clean soil, with no gaps between the well and soil, runoff will flow away from well.

"More than 8 billion chickens and turkeys are killed every year in the USA"

6.3.4.4. General characteristics of coliform bacteria and *Staphylococcus aureus*

The coliform bacteria and *Staphylococcus aureus* bacteria were the main the focus of the current study on the microbiological quality of vegetables irrigated using Litani River water. Fecal coliform bacteria are a group of bacteria that are passed through the fecal excrement of humans, livestock and wildlife. Coliform bacteria are the commonly-used bacterial indicator of sanitary quality of foods and water and considered as an indicator of microbial pollution. The organisms have microbiological characteristics that distinguish them from other microbes. Coliforms are abundant in the feces of warm-blooded animals, but can also be found in the aquatic environment, in soil and on vegetation. In most instances, coliforms themselves are not the cause of sickness, but their presence is used to indicate that other pathogenic organisms of fecal origin may be present. Fecal pathogens are versatile and include bacteria, viruses, protozoa or parasites.

It is widely accepted that the presence *E. coli* in a food or water sample indicates faecal contamination. As a member of the Enterobacteriaceae family, the organism is naturally found in the intestines of humans and warm-blooded animals. Unlike other bacteria in this family, *E. coli* does not usually occur naturally on plants or in soil and water. In human and animal faeces, *E. coli* is present at a concentration of approximately 10^9 g^{-1} and comprises about 1% of the total biomass in the large intestine. Although *E. coli* is a part of the natural non pathogenic faecal flora, some strains of this bacterium can cause digestive system illnesses some of which may cause serious health complications. It should be noted that faecal concentrations of the typical non-pathogenic *E. coli*, used to indicate recent faecal contamination, will always be greater than those of the pathogenic strains, even during outbreaks.

E. coli is generally sensitive to environmental stresses. Its survival time in the environment is dependent on many factors, including temperature, exposure to sunlight, presence and types of other microflora, and the type of water involved (e.g., groundwater, surface water, or treated distribution water). Generally, *E. coli* survives for about 4-12 weeks in water containing a moderate microflora at a temperature of 15-18°C. *E. coli* rarely grows outside the human or animal gut and this combined with its short survival time in water environments means that the detection of *E. coli* in a water system is a good indicator of recent faecal contamination.

In most countries, bacteria are the leading cause of foofdborne diseases and appear to be the causative agents of more than two thirds of the recorded outbreaks. Bacteria causing foodborne infections have the ability to penetrate survive and multiply in host cells. On the other hand, the pathogenesis of bacteria causing foodborne poisoning depends on their capacity to produce toxins after ingestion (in the digestive tract) or before (toxins preformed in foodstuff).

Staphylococcus aureus was chosen to evaluate its presence in raw vegetables because it is widely carried by a large number of healthy individuals as a part of their normal flora. These carriers act as the main the reservoir of the organism and they contribute to the product contamination. It is the third most common cause of confirmed food poisoning cases in the world. The illness it causes is due to the ingestion of preformed toxins produced in foods. The relatively quick progression of staphylococcal food intoxication and an equally quick return to normal health status (for most individuals), it is speculated that most cases are unreported. Ingestion of as little as 25µg of certain staphylococcal enterotoxins results in vomiting and rarely diarrhea after 2 to 6 hours of the consumption of food containing the toxin. Contamination of the foodstuffs may occur at various stages of the food processing including production, sales and distribution.

In addition, *Staphylococcus aureus* is not only an important foodborne pathogen, but can also cause serious wound infections and is becoming resistant to antibiotics. This bacterium is a significant cause of hospital infections, as well as community-acquired diseases.

6.4.Experimental Approach to this Study

In order to carry out this study, appropriate methods were employed. These included collection of vegetables (lettuce, parsley and Malva) and water (surface and ground) samples from various villages along the Litani River in Bekaa valley. Virtually all these villages release untreated waste to the river. The samples were subjected to different analyses using well established procedures to evaluate the microbiological quality of these samples.

The samples collected from various locations in Bekaa Valley. The crops chosen were either irrigated from Litani River or ground water (control). The latter water was collected from wells that varied in depth from 90m to 110m. The locations were localized on a geographical map using a GPS (Global positioning system) machine which indicates the longitude and latitude of these sampling sites relative to sea level then these points were localized in a geographical map by using Google Earth software **(Figs. 8 & 9)**. Determination of the coordinates allowed the ease of re-sampling from the same locations.

"Around $34 billion a year is spent by the food and beverage industry on marketing to the American population. By contrast, the social marketing budget of the National Cancer Institute for its big Five-a-Day campaign, promoting five servings of fruit and vegetables a day, was $2 million"

The main analyses were focused on the presence of *E. coli* and *Staphylococcus aureus*. Relevant procedures were used to confirm the presence (or absence) of these two organisms in the samples collected. The viable number of the organisms in each sample was also estimated.

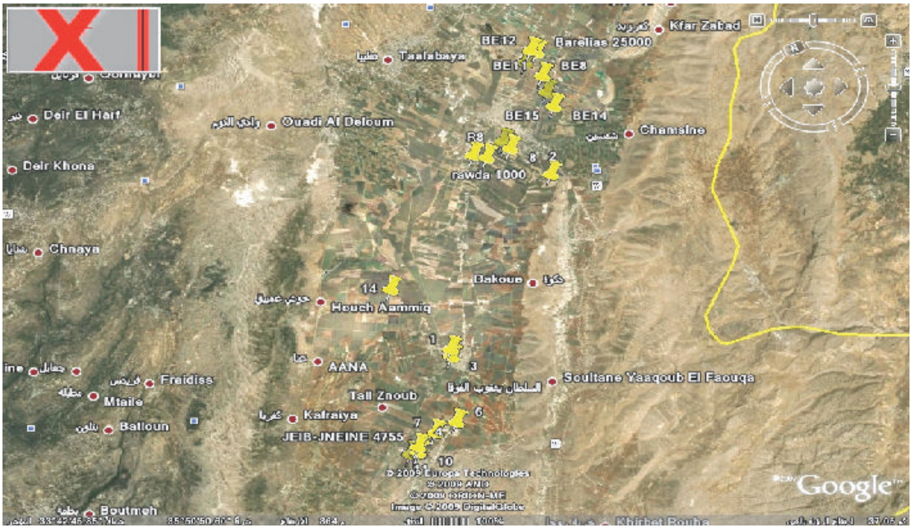


Fig.8 & 9. Yellow pins indicate the locations from where the samples were collected from Bekaa Valley.

Various microbiological estimates of both vegetables and water samples were determined. This involved the enumeration of not only *E. coli* and *Staphylococcus aureus*, but also the viable counts of many other bacteria. Comparison of all of the values obtained helped in evaluating the microbiological quality of the lettuce and parsley samples collected from the Bekaa Valley area **(Fig. 11)**.

When comparing the overall microbiological quality of lettuce samples *vs.* parsley samples, in almost all instances, lettuce samples had higher microbial loads compared to parsley sample. The number of cells of coliforms, *E. coli* and *S. aureus* in lettuce and parsley samples varied from one location to another **(Fig. 10)**. Obviously that depended on the amount of untreated sewage released into the Litani River water and the subsequent use of this water to irrigate the fields from which the samples were obtained. In all cases lettuce had higher bacterial count compared to parsley samples.

"One hectare of land can produce rice or potatoes for 19–22 people per year; the same area produces enough lamb or beef for only 1 or 2 people"

Although some coliform bacteria were detected in vegetable samples irrigated by ground water, neither *E. coli* nor *S. aureus* were present in the control samples. This, of course, indicates the absence of faecal contamination in this water.

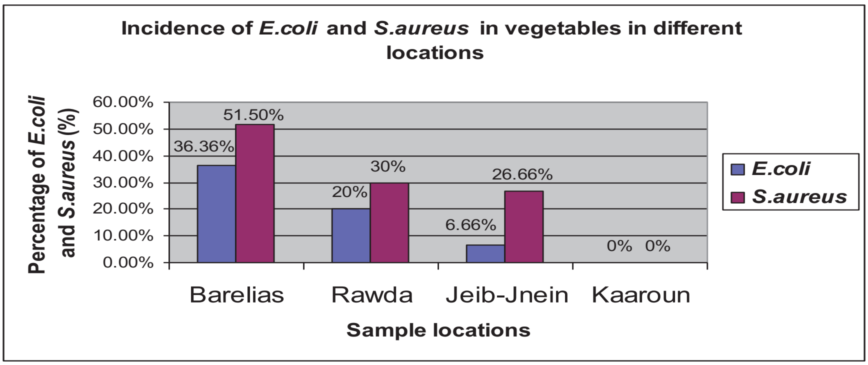


Fig.10. Percentage of S. aureus and E. coli strains isolated from different vegetable samples collected from different locations.

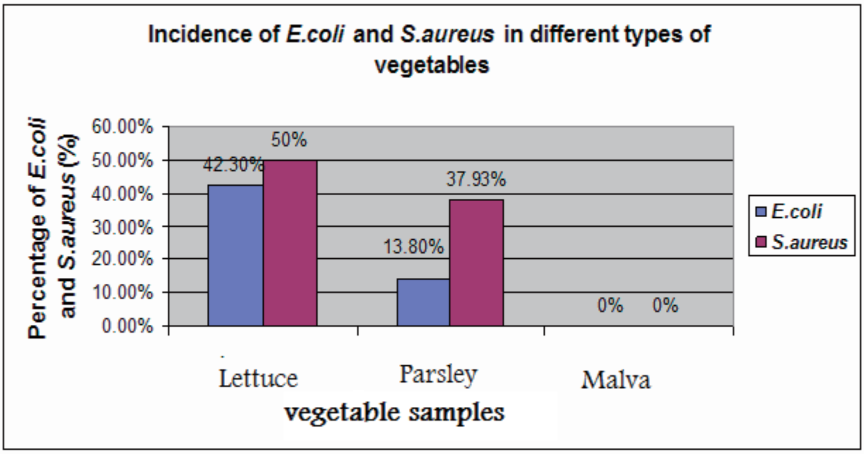


Fig. 11. Percentage (%) of *E. coli* and *S. aureus* strains isolated from different types of vegetable samples irrigated from waste-water Litani River.

6.5. Discussion of the Results Obtained from this Study

Contamination of vegetables with pathogenic microorganisms may occur during growing in the field or during harvesting, post harvesting, handling, processing and distribution. Almost any ready to eat fruits or vegetables that have been contaminated with pathogens either from the environment or from human or animal faces or through storage, processing and handling could potentially cause disease.

Microorganisms on fresh vegetables may come from soil, water, and certain contaminated equipments. Aerobic microorganisms found in food are considered indicators for the microbiological quality of food. Such phenomenon is poorly studied in Lebanon. The large number of aerobic plate count (APC), indicator organisms (coliforms and *E. coli*) and pathogens (*S. aureus*) detected in the food samples surveyed in this investigation revealed that contamination of these foods presented a potential health hazard to consumers in Lebanon especially in Bekaa area.

"One kilogram of beef is responsible for the equivalent of the amount of CO_2 emitted by the average European car every 250 km, and burns enough energy to light a 100-watt bulb for nearly 20 days"

The count of microorganisms in all the vegetable samples tested was similar to other finings findings that have been reported in the USA, Spain and Zambia. Nevertheless, different countries reported a significant difference in the number of organisms present on fresh vegetables. The difference in the counts was probably due to the different cultivation areas of the vegetables and different sources of irrigation. It is worth mentioning that microbial contamination levels may not only vary from one country to another, but also discrepancies occurred within the same country.

For export purposes, it is important that fresh vegetables should not have a total aerobic count exceeding 6.69 $\log_{10}$ CFU g^{-1}, which is the acceptable limit by some countries. Therefore, reducing the total count on the Lebanese products is a priority to ease the economic impact of such contamination.

Hazard Analysis and Critical Control Points- Total Quality Management (HACCP-TQM) Technical Guide-lines lay down the microbial quality for raw foods. Food containing less than 4 $\log_{10}$ CFU g^{-1}, 4-6.69 $\log_{10}$ CFU g^{-1}, 6.69-7.69 $\log_{10}$ CFU g^{-1} and greater than 7.69 $\log_{10}$ CFU g^{-1} (aerobic plate count) are rated as good, average, poor and spoiled food, respectively. Based on these criteria, the data of the present study showed that 84.12 % of our samples could then be regarded as spoiled vegetable food.

The consumption of lettuce as a salad vegetable has increased in recent years, partly due to its nutritional value also because of assumed beneficial health effects. However, it is known to serve as a vehicle of foodborne pathogens and toxins, of which the principal sources of contamination are during cultivation, stages of processing and operations for preparation.

Parsley is a leafy vegetable that has several benefits to public health according to its constituent of vitamins, minerals and fibers. However, there were several outbreaks that resulted from the consumption of contaminated parsley. Parsley and lettuce are widely used in Lebanon; therefore, their impact on Lebanese population will be of great importance.

This is the first study to evaluate the microbiological quality of *Malva* species in Lebanon. *Malva* plant is a natural herbal product which is a valuable source of protein important to the health of people and is traditionally known as a fiber crop. It is a good source of minerals including phosphorus, magnesium and calcium. The present study reported that the total aerobic count on *Malva* samples collected from Barelias ranged from 9.66 to 10.56 $\log_{10}$ CFU g^{-1}. Nonetheless, neither *E. coli* nor *S. aureus* were isolated from these plants. It is important to remember again that coliforms (*E. coli* in particular) can be considered as a hygiene indicator, especially for faecal contamination. Their presence indicates that pathogens might be present due to fecal contamination by human, animal or irrigation water.

The present work showed a statistically significant higher incidence of coliform in all lettuce samples compared to parsley samples.

Several studies from different countries reported the incidence of *Escherichia coli* on a variety of foods. There are several types of pathogenic *E. coli*. The one which is of great importance is enterohaemorrhagic *E. coli* O157:H7which had emerged in recent years as an important foodborne pathogenIt may result in etiological complications and could be associated with high mortality rate in addition to its ability to cause disease through consumption of as little as 10-100 cells only. The main reservoir of this organism is cattle. Therefore, vegetables that are fertilised with animal manure may contain this pathogen which can pose a great threat.

Irrigation with water contaminated by this *E. coli* could also pose a high risk to human health. Bacterial pathogens can reach the interior of the plants by a variety of routes. Once inside, the pathogen may not be affected by surface washing or disinfection. The pathways of internalization can be simple. Bacteria can move with water by capillary action from the stem scar into the core. They can enter through wounds or bruises in the surface of a fruit or leaf of vegetables. Although roots can filter most microorganisms, entry through the roots was noted following experimental flooding with contaminated water.

"Reducing individual meat intake to 70 grams of beef a week would create a carbon sink in the form of 15 million km^2 of abandoned farmland. Greenhouse gas emissions would also fall by 10 % due to the drop in livestock"

S. aureus is a dangerous pathogen and one of the most common causative agents of hospital infections (nosocomial infections) in human beings. Surface of vegetables may be contaminated by this organism through human handling and other environmental factors and can survive for several weeks. Toxigenic *S. aureus* is a major cause of food intoxications and it is the third most common cause of confirmed food poisoning in the world. Human skin and nasal cavity are the main reservoir of staphylococci. Contamination of food stuffs during distribution and handling may allow bacterial growth and subsequently production of toxins which may represent a potential health risk to humans.

In the current investigation, the viable count of *S. aureus* in all vegetable samples collected from different locations in Bekaa Valley ranged from 1.47 to 8.77 $\log_{10}$ CFU g^{-1}. In Lebanon, so far, this is the first study to evaluate the incidence of *S. aureus* in fresh vegetable samples. Similar results were obtained from Taiwan, Turkey and Zambia.

The present study also revealed that 42.30% of lettuce samples carried *E. coli* organisms, which indicates faecal contamination of the product. Such results are in agreement with other reports from Zambia (40%), India (50%) and Spain (27.8%). Studies, in the USA, assessing the bacteriological quality of organic vegetables have found that either *E. coli* was not detected or was present in lettuce in low numbers. Furthermore, 50% of lettuce samples contained *S. aureus*. On the other hand, 13.8% parsley plants harboured *E. coli* compared to 37.93% contaminated by *S. aureus*.

Again, different countries reported different contamination levels. Such discrepancies in the number of organisms present on vegetable samples may be attributed to differences in water hygiene. For instance, in Norway disposal of sewage is properly achieved, unlike that perhaps in Turkey and India. Also, the higher microbial loads on lettuce samples than parsley counterpart may be due to the large surface area of the former leaves. Having foliar surfaces with many folds and fissures this provides good shelter for microorganisms and the fragility of leaves allow the penetration and reproduction of bacteria in their inner tissues. Therefore, parsley samples exhibited low microbial loads possibly due to its small surface area and due to the presence of more resistant tissues compared to that of lettuce.

The microbiological quality of *Malva* species samples showed the absence of *E. coli* and *S. aureus*. No other studies had been done before on *Malva* plants to compare it to. *Malva* plants are considered as an important food used in Lebanon due to its nutritional and medicinal benefits. Several investigations evaluated the antimicrobial ability of *Malva* plants against different microorganisms. This may explain the absence of *E. coli* and *S. aureus* in this study.

"The daily drinking water requirement per person is 2-4 liters, but it takes 2,000 to 5,000 liters to produce a person's daily food"

Overall, going down stream, samples collected from Barelias carried the highest microbial load. This is likely due to the discharge of untreated sewage into Litani River from many villages and towns including Zahle. Moreover, the Litani river and Karaoun lake are seriously threatened by industrial run off from Zahle, Chtoura and Rayak, centers of agro processing (dairy products, wineries, food processing), tanneries and glue factories at Machghara, which discharge non-grading heavy metals such as chrome and arsenic. Agricultural pollution comes indirectly from irrigation and directly from organic waste from farms in the form of manure slurries, silage effluent, and diary washings, which end up returning to man if tracked by the food chain.

Furthermore, there was a correlation between presence of *E. coli* and *S. aureus* i.e. where there was high levels of *E. coli* then a high levels of *S. aureus* had been observed and *vice versa*. This confirms the involvement of untreated sewages and fecal contamination of vegetables.

Agricultural employment of wastewater for irrigation is based on the value of its water content and its constituents which are used as fertilizers. In addition, wastewater also contains salts, toxic metallic compounds, and pathogenic organisms; its contents can also be harmful to the soil, crops, grazing animals, and human health. It has been well established that bacteria, viruses, protozoa, nematodes, and fungi are capable of causing diseases and can be found in foods contaminated with sewage water.

Without water there is no concept of life as it is the basic requirement of almost all living organisms. If water is contaminated then it may cause direct danger to health. So, contaminated water represents a major problem throughout the world by having a negative impact on the environment and human health, where the water contamination is the primary cause of morbidity and mortality.

6.6.Recommendations Resulted from this Investigation

This study demonstrated the potential for disease transmission where microorganisms can survive in soil or on crops and that Litani River water is unsuitable for irrigation of vegetables that are consumed raw. Because neither *E. coli* nor *S. aureus* had been detected in any of the ground water samples, ground water is somewhat safe for irrigation of vegetables in Bekaa.

In conclusion, the present study revealed the potential hazard of raw vegetables collected from Bekaa Valley area which is irrigated from Litani River water that is polluted by untreated domestic and industrial waste. In Lebanon, this is the first study to evaluate the microbiological quality of fresh vegetables grown in Bekaa Valley. These vegetables harboured high microbial loads including aerobic bacteria, coliforms, *E. coli* and *S. aureus* due to irrigation by untreated wastewater in that area.

"One kilo of beef takes around 7 kilos of grain to produce"

The data obtained provide a first-hand indication in which microorganisms might be present in fresh vegetables. The results also indicated that fresh vegetables produced in Bekaa Valley in Lebanon meet some of the international specifications. However, due to the potential microbiological risks of these products, it should be treated directly with certain disinfectant before consumption and to develop highly effective treatments for removing pathogens from a wide range of raw produce.

Prevention of vegetable contamination by microorganisms should be the responsibility of everyone living in these areas by proposing a control measures to minimize the risk of microbial contamination at all points from the field to the table through good agricultural practices and good manufacturing and irrigation practices and the implementation of HACCP programs.

It is highly recommended that waste water (domestic and industrial) should be properly treated before it is released into local rivers and before it is used for irrigating purposes. Bekaa area represents a significant part of the Lebanese agricultural land. Therefore, hygienic practices should be applied at all stages throughout the food chain, "from farm to fork". These include growing, harvesting, transporting, processing and distribution. Public education and consumers' behavior also play a major role in reducing the risk of contamination of raw fruits and vegetables.

Last, but not least, there is a need to further develop and enhance international epidemiological surveillance programmes for foodborne diseases. Collaboration in such programmes, whether between countries or continents, will generate information that will be useful in developing guidelines for reducing the risk of disease that may be caused by raw fruits and vegetables.

References:

- **Abdelnoor AM, Batshoun R, Roumani BM (1983).** The bacterial flora of fruits and vegetables in Lebanon and the effect of washing on the bacterial content. *Zbl. Bakt. Hyg., I. Abt. Orig. B.*177:342-349.
- **Acco. M, Ferreira FS, Henriques JAP and Tondo EC. (2003).** Identification of multiple strain of *Staphyloccocus aureus* colonizing nasal mucosa of food handlers. *Food Microbiology* **20**: 489–493.
- **Canning P, Charles A, Huang S, Polenske KR and Waters A. (2010).** Energy Use in the U.S. Food System. *U.S. Department of Agriculture, Economic Research Service.*
- **Falkenmark M. (2003).** Freshwater as Shared Between Society and Ecosystems: from Divided Approaches to Integrated Challenges, Philos. *Trans. R. Soc. Lond. B. Biol. Sci.* **358:** 2037–2049.
- **FAO. (2008).** The State of Food and Agriculture; *United Nations Food and Agriculture Organization*.
- **Gerbens-Leenes PW and Nonhebel S. (2002).** Consumption Patterns and their Effects on Land Required for Food. *Ecol. Econ.* **42:** 185–199.
- **Halablab MA, Sheet IH and Holail HM. (2011).** Microbiological Quality of Raw Vegetables Grown in Bekaa Valley, Lebanon. *American Journal of Food Technology*; ***6:** 129-139.*
- **Hanafy Holail, Hassan Hammud, Rajaa Fakhoury, and Mahmoud Halablab (2009).** Water Quality of Litani River in Lebanon, *The 15Th Interdisciplinary Conference on the Environment*, July 8-11, The Interdisciplinary Environmental Association, Daytona Beach, Florida, USA.
- **Hoekstra AY and Chapagain AK. (2007).** Water Footprints of Nations: Water use by People as a Function of their Consumption Pattern. *Water Resour Manag.* **21:** 35–48.
- **Hoekstra AY and Hung PQ. (2005).** Globalisation of Water resources: International Virtual Water Flows in Relation to Crop Trade, *Glob. Environ. Change A*. **15:** 45–56.

- **Kantor LS and Lipton K. (1997).** Estimating and Addressing America's Food Losses. *Food Rev.* **20:** 2-11.
- **Kawashima H, Okamoto K, Halablab MA and Bazin MJ. (1997).** System Analysis of Food Supply and Demand in China in the 21st Century. In: Ecosystem and Sustainable Development, Advances in Ecological Sciences, No.1, Editors: J.L. Uso, C.A. Brebbia and H.Power, Computational Mechanics Publications. pp.13-24., ISBN:1-85312-502-4.
- **Liu J and Savenije HHG. (2008).** Food Consumption Patterns and their Effect on Water Requirement in China. *Hydrol. Earth Syst. Sci.* **12:** 887-898.
- **Liu J and Savenije HHG. (2008).** Time to Break the Silence Around Virtual-water Imports. *Nature*. **453:** 587.
- **Liu J, Wiberg D, Zehnder AJB and Yang H. (2007).** Modelling the Role of Irrigation in Winter Wheat Yield, Crop Water Productivity, and Production in China. *Irrig Sci,* **26:** 21–33.
- **Oki T and Kanae S. (2006).** Global Hydrological Cycles and World Water Resources, *Science*. **313:** 1068–1072.
- **Pimentel D and Pimentel M. (2003).** Sustainability of Meat-based and Plant-based Diets and the Environment. *Am. J. Clin. Nutr.* **78 (suppl):** 660S–663S.
- **Pimentel D, Williamson S, Alexander C, Gonzalez-Pagan O, Kontak C and Mulkey, S. (2008).** Reducing Energy Inputs in the US Food System. *Hum. Ecol.* **36:** 459–471.
- **Pimentel D. (2007).** Food, Energy, and Society. Published by Taylor & Francis Ltd.: Hoboke.
- **Pimentel D. (2006).** Impacts of Organic Farming on the Efficiency of Energy Use in Agriculture. *The Organic Center*.
- **Tan M, Li X, Xie H and Lu C. (2005).** Urban Land Expansion and Arable Land Loss in China–a Case Study of Beijing-Tianjin-Hebei Region. *Land Use Policy.* **22:** 187–196.
- **Weber CL and Matthews HS. (2008).** Food-Miles and the Relative Climate Impacts of Food Choices in the United States. *Environ. Sci. Technol.* **42:** 3508–3513.

Recommended Websites:

www.bgr.bund.de/EN/Themen/Wasser
www.gwsp.org
www.hydrol-earth-syst-sci.net/10/455/2006/
www.mwr.gov.cn/
faostat.fao.org/default.aspx

Ibrahim Akoum, PhD
Associate Professor,
Rafik Hariri University

Sustainability and the Food, Water, and Energy Nexus: Socioeconomic Requisites for the Arab Region

"...the "environment" is where we live; and "development" is what we all do in attempting to improve our lot within that abode. The two are inseparable."

Gro Harlem Brundtland
World Commission on Environment & Development

"Today is only one day in all the days that will ever be. But what will happen in all the other days that ever come can depend on what you do today."

Ernest Hemingway, Nobel Prize in Literature

1. Executive Summary.

All economic activity as well as scientific endeavors should aim at benefiting humankind and ultimately cater for the needs of people. More specifically, both science and economics efforts should raise the standards of living of current generations without compromising the interests of future generations. But indeed, this is easier said than done due to one basic foundation of the economics discipline: resource scarcity. Coupled with population growth, scarcity of resources confronts the international community and policy makers with hard choices.

This economic, social, and environmental imperative can be handled most effectively by adopting a mix of policy measures based on a holistic long-term approach that takes into consideration not only current needs and wants but also the sustainability of the development process as well, namely the needs of future generations and their rights for food, water and energy. As such, the interconnectedness among water, energy, and food can only be ignored at our own peril.

This is all the more true in the Arab region which is characterized by relatively high population growth rates, a vastly young population, high levels of unemployment, water shortages, uneven endowment of sources of energy, inadequate institutional frameworks, and weak regional cooperation.

Overall, the global scene has not been very appealing in the past two decades. Economic performance has not been satisfactory, financial crises have been recurring with greater scales and scopes, abject poverty is endemic in much of the world, and environmental threats have persisted. Many argue that as we approach a global population of 9 billion people in 2050, water-food-energy security becomes the paramount concern. Short of that, social and economic stability are in serious jeopardy.

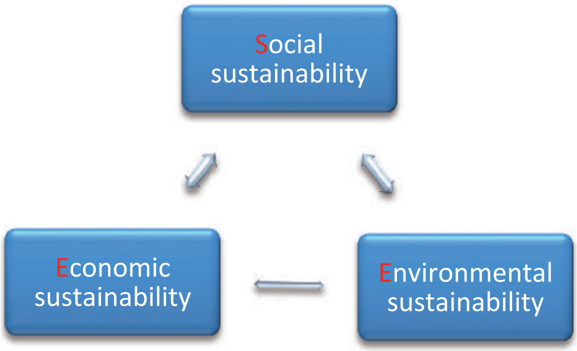
Faced with this reality, global as well as regional policy makers are called upon to change course and adopt adequate policies that are more in line with the spirit of the Earth Summit tenets of 1992. The international community needs to double its efforts to promote Sustainable Developmental Goals (SDGs) to compliment the Millennium Development Goals (MDGs) agreed to in year 2000. The three basic inextricably intertwined constituents of such a sustainable path to development can be best depicted by what could be called the

SEE Nexus, that is the interplay among ***S***ocial, ***E***conomic, and ***E***nvironmental dimensions, as Exhibit 1 shows.

In an attempt to shed light on this aspect of economic and environmental sustainability, including the water, energy, and food (WEF) Nexus, this paper presents the WEF Development Ecosystem approach to highlight the confluence of the various economic and environmental factors in promoting sustainable development, and then addresses the need for a regional approach to the water, energy, and food nexus.

Exhibit 1

The SEE Nexus



The paper concludes by noting that what the world actually needs is a genuine commitment to preserve planet Earth and our ecosystem, move from silos to integration, and above all resort to solidarity rather than racing to the bottom. Environmental challenges are of a global nature and facing them requires a proportionate global stance.

On the regional level in particular, the paper suggests that Arab countries undertake collectively a Water-Energy-Food Nexus For MENA (WEF4MENA) project to explore ways to ensure most efficient production methods and sustainable consumption patterns of water, energy, and food. The basic element of such an approach is resorting to economies of scale by implementing region-wide mega-projects based on individual countries' comparative advantages.

Introduction.

The United Nations Conference on Sustainable Development, known as Rio+20 held in June 2012, portends that around year 2050, world population will expand to 9 billion people, with increasing needs for food, water, and energy. But the Rio+20 declaration laments the course we are on right now on the grounds that it will make the provision of such needs extremely difficult. Further, it argues that current growth patterns are not only unsustainable but also deeply inefficient (World Bank, 2012).

Echoing this point of view, Searchinger (2013) notes that one of the paramount questions facing the world over the next four decades is how to adequately feed about 9.3 billion people in a manner that advances economic development and reduces pressure on the environment.

The World Economic Forum Water Initiative notes that the water, food, and energy are already experiencing shortfalls, and the demand for these resources will increase significantly in the next twenty years, while the world appears ill-equipped to meet the investments and trade-offs required to meet these demands (WEF, 2011).

Substantiating this argument, the International Energy Agency (IEA, 2012) holds that taking all new developments and policies into account, the world is still failing to put the global energy system onto a more sustainable path. According to IEA figures, global energy demand is expected to increase by over one-third in the period to 2035, while providing universal energy access to the world's poor continues to be an elusive goal. In 2011, the UN General Assembly had already established three global objectives to be accomplished by 2030 to ensure universal access to modern energy services, double the global rate of improvement in global energy efficiency, and double the share of renewable energy in the global energy mix (IEA, 2013).

With regard to water security, Bigas (2012) notes that it has become increasingly evident that there will not be enough fresh water on Earth to meet all human needs in the near future unless we change the way in which water resources are managed and that all countries, including those with relatively abundant water resources are facing problems of supply and quality in the face of increased competition for use. What is magnifying the problem is that investment in water management has dropped by more than 25 percent in most countries since the late 1990s, according to data from the World Bank's World Development Indicators database.

As for food security, the Food and Agriculture Organization of the United Nations (FAO) projects that, under current production and consumption trends, global food production must increase 60 percent by 2050 in order to meet the demands of the growing world population. Yet, more than one third of the food produced today is lost or wasted (FAO, 2013).

To come to grips with this thorny issue, the international community has been grappling for decades with how to balance the current needs for growth and development, on the one hand, and environmental concerns and intergenerational equity, on the other hand. For example, the Stockholm Conference held in 1972, clearly states that integrated development planning is needed and should resolve conflicts between environment and development, adding that Earth's capacity to produce renewable resources must be maintained.

Other major efforts in this regard include (a) the World Conservation Strategy of 1980, the influential work of the Brundtland Commission in 1987, (b) Earth Summit in Rio de Janeiro, Brazil in 1992, (c) the third UN Conference on Environment and Development in Johannesburg, South Africa in 2002, and more recently (d) the United Nations Conference on Sustainable Development (Rio+20 summit in

June 2012), which promoted the Social Developmental Goals (SDGs) to compliment the Millennium Development Goals (MDGs) that were previously endorsed by the international community in 2000.

Further, according to the United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil in June 1992, development and environmental protection are interdependent and indivisible. Principle 1 of Rio Declaration proclaims that “human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.” (UNCED, 1992).

The Declaration of the Rio+20 held in June 2012 affirmed the participants’ commitment to sustainable development and to ensuring the promotion of an economically, socially and environmentally sustainable future for our planet and for present and future generations (UNCSD, 2012).

But, despite all the efforts exerted by the international community, environmental concerns are as alarming as ever, while the development process itself has been stuttering and sharply uneven. Indeed, the world socioeconomic development record of the past few decades has been disappointing. Poverty and inequality are endemic in much of the world, food security is still far off, and the sustainable consumption and production of water and energy resources are compromised.

The next section addresses the main features and causes of the current defunct economic and environmental paradigm, thereby underscoring the main shortcomings and impediments facing better cross-sector cooperation and more efficient use and allocation of scarce resources.

2. Global economic, social and environmental performance: Defunct paradigms.

The world economic, social and environmental records have not been satisfactory in the past decade. On the economic front, the global

GDP growth rate has declined to about 2 percent in 2013 compared with more than 5 percent in 2007, as depicted in Figure 1. Economic hardships have been taking a toll on people across countries and financial crises have been recurring more often with greater scale and scope with detrimental contagious effects.

Figure 1.

According to the IEA's World Energy Outlook (WEO, 2012), a lower rate of global economic growth in the short term would make only a marginal difference to longer-term energy and climate trends. This implies that we continue to deplete our resources and damage our climate even with slowing economic activity and production, which casts serious doubts on the allocative and production efficiency of energy. The IEA asserts that we can reduce global energy intensity[1], improve energy security, spur economic growth and mitigate pollution, but current and planned efforts fall well short of tapping full economic potential.

On the poverty front, the incidence of poverty is on the rise and inequality has increased both within and across countries. According to population still lives on less than $10 a day, more than 15 children die every minute due to poverty, one third of world children live without

[1] Energy consumption per unit of GDP
[2] http://www.statisticbrain.com/world-poverty-statistics/

the World Bank's Human Development Report[2] 80 percent of the world adequate shelter, and one of each five children live without access to safe water.

In the global employment market, the International Labor Organization (ILO) warns from an alarming situation that shows no sign of recovering, noting that the number of unemployed worldwide is projected to keep rising to reach 205 million in 2014

As for the environmental aspect of development, the inability of the international community to sustainably manage and preserve energy and water resources is jeopardizing the sustainable development process and our ability to eradicate poverty and achieve the Millennium Development Goals (MDGs). According to the United Nations Environment Programme (UNEP, 2011), many ecosystems are facing mounting pressures from rapid population growth, economic development, biodiversity loss, among other factors, and that the health of the natural ecosystems, in particular those which providing the life-support systems for humans, and the natural foundation for a sustainable green economy are under increasing threat.

With regard to water, it has been argued that there is a structural problem in how water has been managed across the global economy as in many places around the world, policies caused the underpricing, overuse and wasting of water, thereby worsening water security. If it is not tackled, this situation will tear into the global economic system and will start to emerge as a headline geopolitical issue (WEF, 2011).

Likewise, with regard to food security the FAO estimates that 32 percent of all food produced in the world was lost or wasted in 2009 and that about 56 percent of total food loss and waste occurs in the developed world (WRI, 2013). The FAO's most recent estimates indicate that 12.5 percent of the world's population are undernourished in terms of energy intake, concluding that better governance of food systems at all levels is needed to build a common vision to promote effective coordination and collaboration through integrated, multi-sectoral action (FAO, 2013a).

This disconcerting picture and the substandard performance of the international community in this regard has alarmed many in all walks of life including citizens, academics, non-governmental organization (NGOs), specialized think tanks, government bodies, and United Nations organizations.

For instance, the UNEP (2011) laments the conventional model of development that has propelled the growth of nations in the last two centuries contending that it is now recognized for its unsustainable nature. It further notes that the depletion of natural resources and degradation of ecosystems has negatively affected the global environment, concluding that the challenge is to create a political and economic environment that enables society to achieve a balance of societal needs and Earth's ecosystems capacity.

On its part, Dominic Waughray, Head of Environmental Initiatives at the World Economic Forum (WEF) asserts that unless we change the way we use water, we could face a 40 percent gap by 2030 between global demand and what can sustainably be supplied. He warns that if current trends continue, by 2030 increasing water scarcity could cause annual grain losses equivalent to 30 percent of current world consumption (Waughray, 2013). At the Bonn2011 conference, it was argued that if we continue with business as usual we will have – in less than two decades – globally 40 percent less freshwater resources available than we need for ensuring water, energy, and food security for all (Bonn2011).

Clearly, there is a strong and urgent need to change course to better utilize natural resources in a more integrative way in order to ensure food security, energy security, and water security, and enable the most efficient use of these resources and promote sustainable development.

International experiences reveal that failing to recognize the interlink-ages among water, energy and food and the consequences of one sector on another can lead to inefficiencies in the system, since, for instance, “decisions taken on the type of energy generation can significantly influence water demand and in the case of biofuels, displace food production; the way water is sourced, treated, priced and distributed can raise or lower energy requirements; and the choices made on food and diet influence both water and energy needs” (Bonn2011).

This alarming state of affairs stems primarily from poor global governance and the muddled up priorities of the international community. A new global sustainable development paradigm is in order.

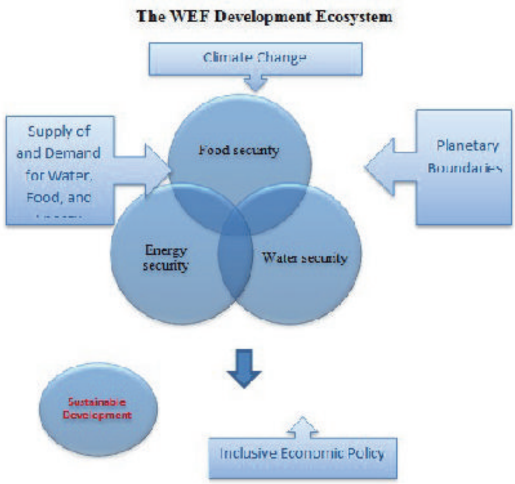
It is in this context that this study supports the Water, Energy and Food Nexus approach. As such, the study asserts that this approach is not merely an engineering and scientific issue, hence the need for devising solutions that go far beyond science and technology requisites to examine the political economy implications and potential challenges to the success of this endeavor. A case in point is first the opposition of some countries to the Agenda 21, and secondly the global economic and financial strains that make it more difficult to secure the needed financial resources to fund sustainability programs and food and energy and water security. This latter issue is all the more important in light of (a) the recurrent global economic and financial crises, along with (b) failure of many donors in developed nations to make good on their official development assistance (ODA) pledges and commitments, and achieving the target of 0.7 percent of gross national product for ODA to developing countries by year 2015.

Where does the Water-Energy-Food Nexus fit within this ultimate global sustainable paradigm?

To proffer an answer to this inquiry we introduce what we call the Water-Energy-Food (WEF) Development Ecosystem (Exhibit 2).

According to this concept, sustainable development is the epicenter of efforts to promote productive and allocative efficiency as the world makes use of scarce resources. The Water-Energy-Food Nexus is but one tributary.

Exhibit 2



As shown in Exhibit 2, in addition to the WEF Nexus, other dimensions of sustainable development include inclusive economic policy, planetary boundaries[3], climate change, and supply of and demand for water, food and energy. The former three factors are of particular relevance to the WEF Nexus, which is stated in “The Future We Want” document of the Rio+20 conference in 2012. In Rio+20 the international community expressed its deep concern that all countries, particularly developing countries, are vulnerable to the adverse impacts of climate change that are already threatening food security and efforts to eradicate poverty and achieve sustainable development (UNCSD, 2012).

-Climatic change is key for the WEF Development Ecosystem. It is widely agreed that climatic change affects all natural system

[3] The planetary boundaries concept was introduced in 2009 to refer to a set of planetary boundaries that if crossed could generate abrupt or irreversible environmental changes.

including the water cycle, sea levels, and ocean circulation to the productivity of natural and agricultural systems, and the survival of plant and animal species, thus influencing human welfare, through changes in supply of and demand for water, food and energy, and affecting the sustainability of the current socio-economic and environmental systems (Simonovic, 2013).

With regard to planetary boundaries, it can be argued that the industrial revolution has been an inflection point in our history with regard to how human kind has dealt with the ecology. Many hold that human actions have gradually become the main driver of global environmental change and that once human activity has passed certain thresholds or tipping points, defined as "planetary boundaries", there is a risk of "irreversible and abrupt environmental change" (UN, 2012). Naturally, this has direct consequences on the security of water, energy and food.

As for the supply of and demand for water, energy and food, growing populations increase the demand for water, energy and food, and the way we supply and make available these resources has a direct impact on their availability for future generations, hence the exigency for the efficient production and allocation of these resources, which makes the WEF Nexus all the more important.

3. The Water, Energy and Food Nexus and the Arab region.

The Arab region, with a population of about 363 million people, constitutes around 5 percent of world population, and is endowed with large amounts of fossil energy, in particular, oil and gas, in addition to ample human, financial, and natural resources. As shown in Exhibit 3, the region stretches from the shores of the Atlantic Ocean in North Africa to the Arabian Sea in the Asian continent with differing terrains.

Exhibit 3.

The Arab countries account for nearly 58 percent of the world's total proven crude oil reserves and about 30 percent of the world proven natural gas reserves. In addition, the region enjoys a very promising potential of renewable energy resources such as hydroelectric power, solar energy, and wind resources (see Box 1).

Further, we grew up in the Arab World hearing that Sudan, for instance, has the potential to feed the entire region and that Egypt fed the Roman Empire, but now they can barely feed themselves. Sudan, for example, has about 200 million acres of arable land with abundant water resources. According to the World Bank (2011), Arab countries import around 56 percent of the cereal calories they consume, and some countries in the region import 100 percent of their wheat consumption needs. This obviously exposes the region to serious food security threats, especially in view of the food price shocks in the past few years. Based on an estimated population growth rate of 3.5 percent, the cost of the Arab world's food imports is expected to reach $115 billion by 2020 (Worldfolio, 2013).

Box 1. Overview of the energy sector in the ESCWA Region.

1. Oil and gas sector is the largest economic sector is the Region.
2. Proved reserves: oil 53% and natural gas 27% of the world reserves.
3. Oil and gas exports represent more than 90% in some ESCWA countries GCC countries.
4. There are still energy access problems: more than 20% of the population does not have access to energy services, especially in the electricity sector.
5. The electric power sector is dominated by thermal power generation (more than 95%).

There is a problem of energy efficiencies in production and consumption (which requires improvement) and renewable energies uses in ESCWA Region. Main reasons are:

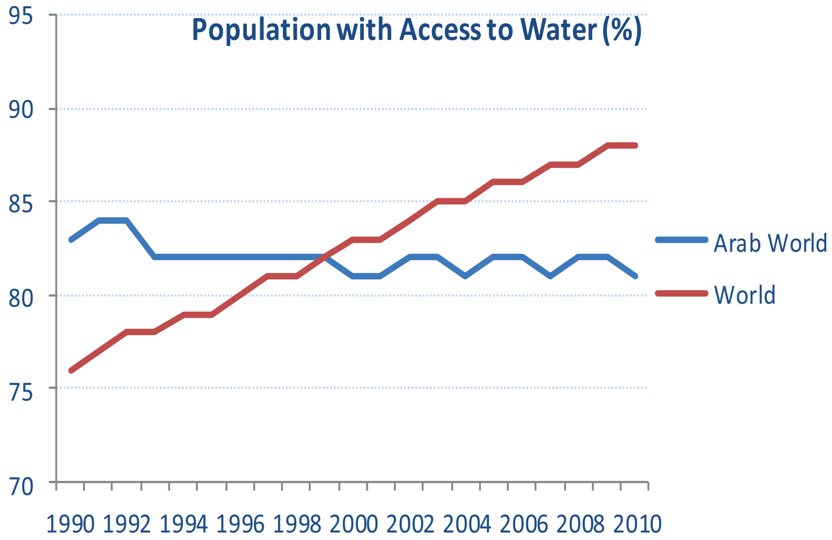
1. Financial: high investment needs/ Subsided Electricity Tariffs and oil-gas Prices.
2. Social: weakness of awareness.
3. Institutional
4. Technical: needs for technologies and knowledge transfer.

Source:
http://www.unece.org/fileadmin/DAM/energy/se/pp/gee21/1_ahge_June10/17_Item4_Al_Deghaili.pdf

In addition, some countries in the region are severely water-stressed and water resources constitute a main challenge, not only for the Gulf Cooperation Council (GCC) member countries and the Arab countries in North Africa. Managing water resources is also an issue to contend with even in countries that have relatively better water sources.

As figure 2 below shows, while the percentage of world population with access to water has increased from about 76 percent in 1990 to 88 percent in 2010, the percentage of the Arab World's population with access to water has declined from 83 percent in 1990 to 81 percent in 2010.

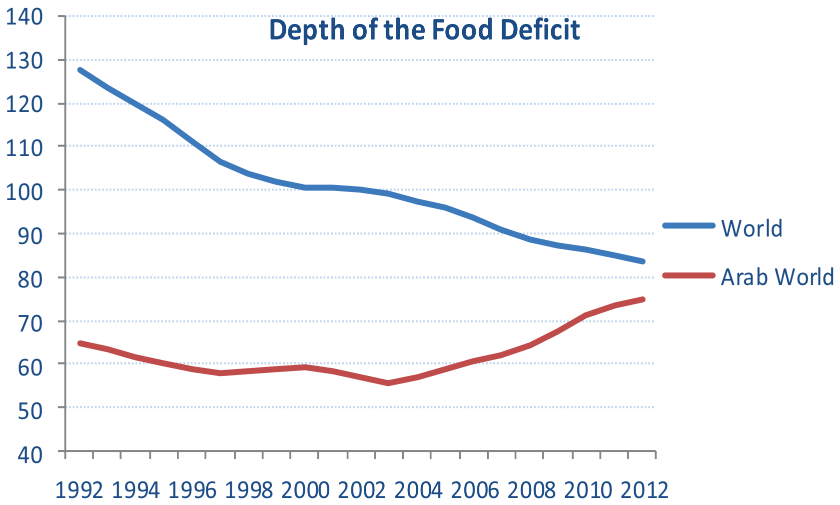
Figure 2.



Likewise, the Arab world has not been faring well either with regard to the depth of the food deficit which indicates how many calories would be needed to lift the undernourished from their status. As shown in Figure 3, as the depth of the food deficit declined markedly since 1992 globally, the situation in the Arab region has worsened with the deficit increasing from about 65 in year 1992 to 75 in year 2012. In particular, after registering some improvement, the last decade has seen deterioration in the food deficit.

According to the United Nations Environmental Program (UNEP, 2009), since 1990 demand for energy in the Arab countries has risen in response to rising populations, rural-urban migration, and widespread subsidies. The UNEP notes that overall per capita freshwater availability has fallen, while consumption has risen, necessitating improvement in the efficiency of energy production and consumption patterns in the region. In turn, the ESCWA (2012) noted that the Arab countries face mounting challenges in the water and energy sectors not only because of population pressure but also environmental pressure, including lack of water, desertification, pollution, global warming and climate change.

Figure 3.



It is unfortunate that while commanding such an immense amount of human, natural, and financial resources and great potential, as outlined earlier, the Arab region still suffers from poverty, water shortages, sanitation problems, and energy difficulties. Strategic strengths have not been used to create strategic opportunities for the region. The culprits are numerous, the most critical of which are the lack of cross-sectoral linkages and factual regional approaches. For instance, according to the Stockholm Environment Institute (SEI, 2012), in the MENA region, as in most of the world, water and energy have historically been managed separately, with little consideration of cross-sectoral interactions, but by addressing water and energy together, planners can identify crucial interactions, conflicting demands and potential synergies.

The recognition of these challenges is not new. It is back in 2001 that the Arab Ministerial Declaration on Sustainable Development (AMDSD) was adopted by the Arab Ministers Responsible for Development, Planning and Environment, and identified the main constrains facing sustainable development in the Arab countries. The Declaration pointed at the severe arid nature of the region, little and sparse rainfall, frequent droughts and spread of desertification, limited areas available for agriculture, water scarcity, and shortage of non-renewable sources of energy. The Declaration also pointed at the adoption of technologies and approaches that are not suitable for the social, economic and environmental conditions of the region, and the limited capacity of academic and research institutions, and the relatively limited experience of the civil society in participating in the process of development and implementation of sustainable development programmes and activities (AMDSD, 2001).

At the 3rd Arab Economic and Social Development Summit in Riyadh in January 2013 the leaders of Arab countries confirmed their commitment to creating the investment climate in their countries and enact national laws and legislation that will help to attract more investment and utilization of natural resources and comparative advantages enjoyed by our countries. This is a sign of departure from the outdated self-sufficiency doctrine (see Box 1).

Box 2. Saudi Arabia: Overseas investments to boost food security

Until six years ago, the Kingdom's policy makers advocated self-sufficiency for its local wheat cultivation, as well as some other products such as milk, meat and eggs. However, as it became clear that levels of subsidies required for farmers and limited water resources were making domestic wheat production unviable, the government decided to gradually wind down operations and opt instead to meet their wheat requirements through imports. The Kingdom is expected to phase out domestic wheat production completely by 2016, as farmers are encouraged to shift their focus toward alternative crops.

Source:http://www.oxfordbusinessgroup.com/economic_updates/saudi-arabia-overseas-investments-boost-food-security

In addition, the leaders adopted the Arab strategy for the development of renewable energy applications (2010 - 2030), directed the relevant bodies and organizations to work on the speed of implementation of the Emergency Programme for Arab Food Security, and pledged to closely follow the implementation of the 'Strategy for

Water Security in the Arab Region' and 'Integrated Water Resource Management Project (IWRM)' (AESDS, 2013).

In 2003, Arab Ministers of Energy and Ministers of Environment issued the Abu Dhabi Declaration on Environment and Energy in which they expressed their political commitment to developing a more effective role of the energy sector in achieving sustainable development in the region. The declaration emphasized the importance of promoting regional energy integration projects, particularly electric grids interconnections and natural gas networks (ADDEE, 2003).

The “Borderless Energy” initiative, a component of the Arab Strategy for developing uses of renewable energy for 2010-2020, is an example of such integrative steps. The aim of this endeavor is to use renewable energy, strengthen the process of electricity linkage among member states of the Arab League, and encourage export of renewable energy among countries that are part of the energy grid. In addition to promoting competition and efficiency in the sector, it will help making available the needed funds to finance such ambitious energy projects.

An ambitious project has been established at Qatar Foundation and tailored for Qatar in which a new tool is to be developed to identify sustainable resource management strategies governed by the Water-Energy-Food Nexus. This undertaking is predicated on the idea that a high level of interconnectedness exists between the three resources that form a nexus which itself is affected by a host of external economic, social, and environmental factors. It is argued that recognizing the intimate connection between these resources is necessary to move to more integrative approach for resource management (QEERI, 2013).

What are the requisites for an effectual Water-Energy-Food Nexus in the Arab region?

Achieving real progress in realizing the Millennium Development Goals (MDSs) in the Arab countries makes it imperative to adopt a revised approach to tackle social and economic development issues.

Such an approach must be based on collective regional programs and actions, as opposed to individual country efforts. The successful implementation of this new paradigm rests on a number of main pillars, namely, political commitment, collaboration of public and private sectors, sound economic policies, active regional research centers with comprehensive data platforms, and regional clusters of production based on individual country resource endowments.

This ambitious undertaking requires establishing adequate legal, regulatory, and institutional frameworks both at the national and regional levels, in addition to vast comprehensive regional data platforms to support regional research centers in scientific efforts as well as formulation proper public policy issues.

First, achieving sustainable development and sustained water, food, and energy security requires a closer collaboration between science and public policy. It is imperative to garner political commitment of all major countries in the region to support scientific endeavors to find ways to foster efficient and sustainable production and consumption of water, energy and food.

Regional declarations on sustainable development that have been presented at previous conferences, both in the region and internationally, have often expressed ambitious goals with little concrete action in support of them. The current political situation presents both the opportunity and the need to go beyond that (ESCWA, 2011).

Second, the magnitude and complexity of the Water-Energy-Food Nexus and the financial, scientific, engineering, and technological requirements requires both public and private sector resources and efforts in the form of public-private partnerships. Indeed, international experience and good practices show that both the private sector and government should team up on managing this important undertaking. According to the WEF (2011), an unfettered reliance of markets will not deliver the social, economic, and environmental outcomes needed.

As such, good regulation in water is indispensable and a multistakeholder effort to improve the management of our future water needs is an urgent, practical and resolvable issue.

In this context, the Arab civil society has a significant role to play through assisting in raising public awareness campaigns to dispel the myth that sustainable development is a mere environmental issue and secure wide participation in sustainable consumption and production of water, energy, and food. In the Arab region, where public ownership of resources is significant, and where citizens do not pay the actual cost of energy-related products, the society is not fully aware of the real cost of consumption and production of such products. The public should be made aware of the high social cost of producing water, energy, and food, as opposed to mere economic cost.

Third, international experiences imply that the lesson the Arab region should heed is that good governance and adequate economic policies are essential ingredients in the sustainability quest. It has been proven that weak governance systems, distortions from perverse subsidies and unsustainable investment can exacerbate a set of unintended consequences resulting in sub-optimal allocation of resources and an inability to meet accepted norms of water, energy and food security (Bonn2011). For instance, the renowned expert in sustainable development and former Prime Minister of Norway, Gro Harlem Brundtland asserts that "it is the slowness of institutional adjustments to water scarcity that has made the global water crisis one of governance more so than a crisis of absolute water availability. We are not facing water scarcity so much as we are facing water governance issues" (Bigas, 2012) .

Fourth, establishing research centers with highly qualified scientists and equipped with comprehensive national and regional databases on various sustainable development related indicators is an important requisite to have a successful Water-Energy-Food Nexus. This is essential to craft actionable programs as well as measure and track progress in achieving agreed targets. This effort contributes to regional capacity building in this field and encouraging innovation and the use of more efficient technologies. At the regional level, this requirement has been acknowledged by the Abu Dhabi Declaration on Environment and Energy adopted in 2003 which called for the establishment of an environmental database at the level of the Arab world as a whole to encourage the exchange of information (ADDEE, 2003).

Fifth, and above all, in light of the magnitude of the development challenges the Arab region is facing, and given the various endowments the region enjoys, and the need to make the best use of these available resources, the region's best hope is to resort to economies of scale and economies of scope and implement region-wide mega-projects based on individual countries' comparative advantages.

Synergies generated from regional cooperation are expected to be enormous as the member countries of the Arab region have varying human, financial, and natural resource endowments.

In addition, a regional approach could open up new finance options, such as enhanced access to global climate funds or the creation of a dedicated MENA climate fund, perhaps, through the OPEC Fund for International Development (SEI, 2012).

The Arab Ministerial Declaration on Sustainable Development, adopted in 2001, has recognized the importance of an integrated Pan Arab strategy to achieve sustainable development. In particular, it noted the importance of judicious utilization of resources, the establishment of an environment conducive for investment at the national and regional levels, and strengthening of the role of the private sector and civil society in the formulation and implementation of sustainable development plans. The Declaration also highlights the need for regional cooperation on the finance side calling on further developing Arab and Islamic funds to participate in financing sustainable development.

A series of high-level agreements and initiatives starting in the mid 1980s were conducted to reinforce regional activities and the establishment of regional institutions and organizations to address sustainable development issues. However, the ESCWA (2011) reveals that governance institutions in the Arab countries still fall short of what is necessary to achieve sustainable development in the region, and though the goal of integrating economic, social and environmental issues in development decision-making has been expressed in numerous regional declarations, concrete actions to achieve it have been limited.

International experiences confirm the benefits generated from regional cooperation in the areas of water, energy, and food. For instance, it is argued that the lessons learned widely in the world is that the failure of governance with respect to water management is often a failure to integrate water management at different levels and to take local and regional approaches into consideration (Bigas, 2012). Box 2, presents a case of success of regional cooperation that results in optimal levels of water and food.

With regard to energy, the IEA (2012) notes that energy efficiency can improve energy security, spur economic growth and mitigate pollution, but current and planned efforts fall well short of tapping the full economic potential. This assertion holds true in the Arab region, too. Sustainable consumption and production (SCP) can only be attained through the efficient handling of the energy resources, which can be best achieved through region-wide projects.

The importance of a regional approach is recognized also by the United Nations studies as a means for higher efficiency and energy savings. The UN (2013) exhorts the international community to do more to strengthen integrated national and regional infrastructure for energy supply, transmission and distribution systems, noting that stronger measures and incentives that emphasize energy efficiency and energy savings must be put in place.

This notion is brought to the fore by the ESCWA (2011) which hold that national goals and priorities are often premised on national security, economic growth and cultural preservation rather than on the sustainability of national and regional development. As such, it is this kind of sustainability that the Arab countries ought to seek. All other approaches have proven unsatisfactory.

Box 3. The Global Water Crisis: Framing the Issue.

Regional cooperation is essential to creating transboundary relationships that result in optimal levels of water, food and health security for all users sharing a particular river system. International examples, such as that of the Nile River Basin, suggest that effectively orchestrated basin-scale management of water resources can generate increased benefits for all within a regional context if there is cooperation between all stakeholders.

Another important example of successful international agreements over water management standards is the European Union (EU) Water Framework Directive. In this framework, water quality standards and parameters of aquatic ecosystem health are defined by the EU, but individual nations are charged with meeting those standards based on the strategy they decide will work best in local circumstances. Furthermore, the EU model links both agricultural and water policy, and it is a model which may be useful to examine in other regional contexts, such as in North America.

Sources:http://inweh.unu.edu/wp-content/uploads/2013/05/WaterSecurity_The-Global-Water-Crisis.pdf

4. Policy recommendations: From silos to integration.

Meeting the challenge of sustainable development in the 21st Century will mean finding comprehensive solutions at local, national and global levels through concerted action and shared responsibility (UNGA, 2013). Yet, it is disconcerting that the international community squanders massive amounts of resources on non-productive activities and can secure hundreds of billions of dollars to wage wars everywhere, but fails to make available a meager portion of these funds to act with "shared responsibility" and wage wars on abhorring global calamities such as environmental damage and abuse of natural resources, and thereby ensure water, food and energy security for current and future generations.

In a word, the current economic international system is defective and a new paradigm is in order. It is not simply scarcity of resources that is plaguing the world, but it is rather the misuse of resources and their improper distribution (Akoum, 2008).

With regard to the Arab region and the water and energy resources, in particular, the ESCWA (2012) contends that the region needs a new, comprehensive and systematic methodology to approach the water and energy nexus in a sustainable way.

The new paradigm ought to be based on commonality rather than disparaging competition and on solidarity rather than adversity and myopic self-interest. What is needed, then, is better governance of the social and economic development processes and better use of available resources. In this context, the archaic national self-sufficiency doctrine is not viable in the Arab region and short-sighted nationalist considerations need to be replaced by a regional integrative approach to sustainable development which would benefit all.

This paper proposed a conceptual framework for a Water-Energy-Food Nexus For MENA (WEF4MENA) to be adopted and undertaken by the Arab countries in order to explore ways to ensure the most efficient production and consumption patterns of water, energy, and food taking into account the economies of scale of regional mega-projects, rather than local less efficient production schemes. Comparative advantages of individual Arab countries should be the main criterion and guiding light to ensure most efficient and sustainable consumption and production patterns. Absent this condition, the actual social cost of producing water, energy, and food would be underestimated, thus derailing any effort toward identifying and achieving Sustainable Development Goals (SDGs).

In a word, sustainable development can only be achieved in an integrative fashion and requires an interdisciplinary orientation where the technological and engineering requisites work side by side with the political, social and economic dimensions of this process. It is an inclusive process. As such, the main requisites as described earlier are political commitment, collaboration of public and private sectors, sound economic policies, active regional research centers with comprehensive data platforms, and regional clusters of production based on individual countries' resource endowments and comparative advantages.

Bibliography

- ADDEE, 2003. "Abu Dhabi declaration on environment and energy". https://www.ead.ae/TacSoft/FileManager/Conferences%20&%20Exhibitions/2003/44-AbuDhabiDeclaration-Eng.pdf
- AESDS, 2013. Conclusion of the Third Arab Summit for Economic and Social Development . http://www.mofa.gov.sa/sites/mofaen/aboutMinistry/ConferencesAndSeminars/ThirdArabianEconandSocialSummit/SummitNews/Pages/ArticleID201312215441134.aspx
- Akoum, I., 2004. Governance and Globalization: An Economic and Financial Approach, Union of Arab Banks Publication, Lebanon. www.uabonline.org.
- Akoum, I., 2008. Globalization, Growth, and Poverty: The Missing Link. *International Journal of Social Economics*, Vol. 35 No. 4, 2008, pp. 226-238.
- AMDSD, 2001. Arab Ministerial Declaration on Sustainable Development. http://www.escwa.un.org/divisions/sdpd/wssd/arab.html
- Axworthy, T., and Bob Sanford, 2012. "The Global Water Crisis: Framing the Issue". http://inweh.unu.edu/wp-ontent/uploads/2013/05/WaterSecurity_The-Global-Water-Crisis.pdf
- Bigas, H. (Ed.), 2012. The Global Water Crisis: Addressing an Urgent Security Issue. Papers for the InterAction Council, 2011-2012. Hamilton, Canada: UNU-INWEH. http://inweh.unu.edu/WaterSecurity/documents/WaterSecurity_FINAL_Aug2012.pdf
- Bonn2011 Conference, 2011. The Water, Energy and Food Security Nexus – Solutions for a Green Economy.
- ESCWA, 2011. "Regional review of institutions for sustainable Development in the Arab region". United Nations - New York, 2011.
- ESCWA, 2012. "Intergovernmental consultative meeting on the water and energy nexus in the ESCWA region". Report, Beirut, 27-28 June 2012.
- FAO, 2013. "Food Wastage Footprint". http://www.fao.org/nr/sustainability/food-loss-and-waste/en/
- FAO, 2013a. The State of Food and Agriculture 2013.

- IEA,2012.“World energy outlook 2012 factsheet. http://www.worldenergyoutlook.org/media/weowebsite/2012/factsheets.pdf
- IEA, 2013. “Global Tracking Framework”. http://www.iea.org/publications/freepublications/publication/globaltrackingframework.pdf
- IISD, 2013. “Summary of the Arab regional Implementation meeting on RIO+20” http://www.iisd.ca/download/pdf/enb05309e.pdf
- Mohtar, R.H., and Daher, B. 2012. Water, Energy, and Food: The Ultimate Nexus, Encyclopedia of Agricultural, Food, and Biological Engineering, Second Edition.
- Oxfordbusinessgroup, 2013. “Saudi Arabia: Overseas investments to boost food security”. Oxford Business Group, 9 May 2013. http://www.oxfordbusinessgroup.com/economic_updates/saudi-arabia-overseas-investments-boost-food-security
- QEERI, 2013. “Water-Energy-Food Nexus Tool”. Accessed in October1, 2013. http://qeeri.org/research-enabl/water-energ-food
- Searchinger, T. et al., 2013. “The Great Balancing Act.” Working Paper, Installment 1 of Creating a Sustainable Food Future. World Resources Institute. http://www.worldresourcesreport.org.
- SEI, 2012. “Climate Change, Water and Energy in the MENA Region: Why a ‘Nexus’ Approach is Crucial for Mitigation and Adaptation”. Discussion Brief.
- http://www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-DB-2012-MENA-climate-nexus.pdf
- Simonovic, S., 2013. “Are we modeling impacts of climatic change properly?”. *Hydrological Processes, 20, 431-433(2006).*
- UN, 2012. “Resilient People, Resilient Planet: A Future Worth Choosing”.
- http://www.un.org/gsp/sites/default/files/attachments/GSP_Report_web_final.pdf
- UN, 2013. Abu Dhabi International Renewable Energy Conference, May 2013. http://www.un.org/en/development/desa/usg/statements/mr-wu/2013/01/sustainable-energy-for-all-2.html
- UNCED, 1992. Rio Declaration on Environment and Development. http://habitat.igc.org/agenda21/rio-dec.htm
- UNCSD, 2012. Report of the United Nations Conference on Sustainable Development. http://www.uncsd2012.org/content/documents/814UNCSD%20REPORT%20final%20revs.pdf
- UNEP, 2009. “Arab Regional Strategy for Sustainable Consumption and Production”. http://www.unep.fr/scp/marrakech/publications/pdf/Final%20Draft%20Arab%20Strategy%20on%20SCP%20-%2006-10-09.pdf
- UNEP, 2011. “Restoring the natural foundation to sustain a Green Economy”. UNEP-IEMP Policy Series paper. http://www.unep.org/ecosystemmanagement/Portals/7/Documents/Policy%20Series-

Restoring%20the%20natural%20foundation%20to%20sustain%20a%20Green%20Economy.pdf
- UNGA, 2013. “Sustainable development and climate change: Practical solutions in the water-energy nexus”. http://www.un.org/en/ga/president/67/letters/pdf/Thematic%20Debate_Sust.Development%20and%20Climate%20Change%20-%2021%20March%202013.pdf
- Waughray, D. 2013. “The water crisis in facts and figures”. http://forumblog.org/2013/08/the-water-crisis-in-facts-and-figures/
- WEF, 2011. “Water Security”. The World Economic Forum Water Initiative.
- WEO, 2012. World Energy Outlook 2012 Factsheet. http://www.worldenergyoutlook.org/media/weowebsite/2012/factsheets.pdf
- World Bank, 2011. “The Grain Chain: Food Security and Managing Wheat Imports in Arab Countries”. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/04/20/000333038_20120420012053/Rendered/PDF/681840BRI00PUB0portsinArabCountries.pdf
- World Bank, 2012. High Stakes at Rio: The World Bank's Key Issues for Rio +20 http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTSDNET/0,,contentMDK:23200243~menuPK:64885113~pagePK:7278667~piPK:64911824~theSitePK:5929282,00.html
- Worldfolio, 2013. “Sudan ready to support food security”. http://www.worldfolio.co.uk/region/middle-east/saudi-arabia/ali-ahmed-karti-minister-of-foreign-affairs-oic-n2366
- WRI, 2013. “Creating a Sustainable Food Future, Installment Two: Reducing Food Loss and Waste. World Resources Institute”. www.wri.org/publication/reducing-food-loss-and-waste

Ali Karnib, PhD
Water Resources Expert

The Water, Food and Energy Nexus in the Arab Region

1. Inclusive Water, Food and Energy Nexus Approach

Three modeling approaches are commonly used to deal with the nexus approach:

The optimisation model approach: This approach consists of aggregating all the relevant decision variables related to the nexus in one economic equation. The model (equation) could be linear or nonlinear. The solution of this model is to find the decision variables that maximize the economic equation.

The multicriteria decision making approach: This approach consists of defining different scenarios or alternatives related to the nexus, then evaluating those scenarios in accordance with various criteria or aspects such as the economical, technical, environmental. It consists of ranking the scenarios from best to worst, using multi-criteria analysis techniques.

The inclusive approach: The particularity of the water, energy and food nexus comes from the engagement of three important sectors, not as stakeholders, but on equal grounds as partners sharing the decisions related to water, energy and food security strategies and plans. Inclusive management process is one of the best approaches that could be used to "*help people with different orientations and ways of understanding and valuing policy problems and solutions to work together to propose and take action*" (Feldman and Khademian, 2007). This way of handling the nexus provides an informed and transparent framework for determining and resolving trade-offs across sectors and other policy areas such as climate change and shared water resources.

A water energy food nexus approach requires addressing the following:

a) Identifying relevant stakeholders who can serve as intermediaries for bridging water, energy and food security decision-making (an inclusive community of participation)

b) Identifying and acquiring pertinent physical and technical data

c) Quantifying physical inter-linkage equations

d) Building an inclusive soft platform that serves to generate different options and scenarios and evaluate cross-sectoral impacts, also serves as a database helping to fill gaps in knowledge on the nexus.

This approach can offer opportunities to set up and facilitate processes that promote information exchange and the ability to understand the perspectives of the different partners. It can also offer opportunities to create relationships that enable people to work together to address problems.

The aforementioned second and third approaches necessitate tools to generate scenarios. Several Water, Energy and Food Nexus tools do exist and could simulate and generate scenarios at the river basin and watershed levels. An example of such tools is the linking of the Water Evaluation And Planning System (WEAP - software tool for Integrated Water Resources Planning) with the Long-range Energy Alternatives Planning system (LEAP - software tool for Energy Policy) in order to analyze the nexus at the river basin level (SEI, 2012) (Rogner H.H. et al., 2012). These tools could also be used to examine the nexus at the national level, by analyzing scenarios for all the river basins or watersheds in the country. They could be used as well for nexus analysis at the regional level in the context of shared river basin analysis where the concerned countries need to prioritize, in the management of the shared water resource, between drinking, agriculture or energy production. While using these tools attention should go to the following:

a) The need to collect large quantity of hydrologic data

b) The need to use more than one technical tool

c) The need to manually build the inter-linkage equations between the different technical tools

d) Lack of inclusivity at the nexus level.

Therefore, in order to overcome the above mentioned drawbacks, it is necessary to develop regional common platform, to serve as basis for dialogue, priority setting and policy formulation on the nexus at the regional level.

2. The need for a quantitative data on the nexus in the Arab region

In order to build a nexus system in the Arab region, a quantitative data related to the system is needed. The data should comprise the following:

2.1 The energy requirements for water

It is important to quantify the intensity and the cost of energy for pumping groundwater, desalination, water treatment, water transmission and water distribution in the various Arab countries. Having accurate knowledge about the intensity and cost of energy for water would permit to compare between different water sources options.

2.2 The water requirements for oil extraction and refining

No accurate data base is available with regards to the average estimations of the water requirements for oil extraction and refining in the Arab countries. The amounts of water required for oil extraction must be estimated by installing and calibrating water meters in each oil extraction and refining facility, to accurately quantify those amounts.

2.3 The water requirements for electricity production in the Arab region

A large number of the installed electric capacities in the Arab region rely on freshwater cooling. It is important to quantify water requirements for electricity production in the Arab countries for accurate nexus analysis.

2.4 The water and energy requirements for food production and processing

The food and agricultural sector has traditionally used energy directly in the form of fuel and electricity, and indirectly through the use of energy-intensive inputs, such as fertilizers and pesticides. It is important to investigate the food and agriculture sector's relationship with energy, both by using energy as an input into agricultural production and through supplying agricultural feedstocks for use in biofuel production.

It is worth mention that the agricultural sector in the Arab region accounts for 80-90 percent of the Countries' consumptive water use. The expansion in water demands- to support population and economic growth, environmental flows and energy-sector growth, combined with supply/demand shifts expected with climate change, will create new challenges for the agricultural water use and conservation in the Arab region. Despite technological innovations, at least 70% of the irrigated cropland acreage in the Arab region still depends on a less efficient and traditional irrigation application systems. It is important to investigate the agriculture sector's relationship with water, both using water as an input into agricultural production and importing water in agricultural products as virtual water.

3. Promoting wastewater reuse

This paragraph is presented to illustrate the importance of reconsidering wastewater reuse as a water source option for agricultural, municipal and industrial use. The necessity to reuse wastewater is derived by the low energy cost for wastewater treatment compared to energy cost for other water production sources. Moreover, if anaerobic wastewater treatment technology is used, wastewater treatment could be carried out without any external energy supply (by using the produced methane gas). In addition to energy saving, this option includes other benefits such as preserving the environment and reducing CO_2 emissions.

4. Conclusions and further development

Providing water, energy and food sustainably in the contexts of economic growth, population increase and climate change is the main challenges facing the countries of the Arab region. The need for adopting inclusive planning and management policies for the water, energy and food resources in the Arab region is extremely important. There are existing regional mechanisms working at a sector level, but more is needed to allow them to interact and engage one another in their priority setting exercises, analytical and decision-making process.

There are massive knowledge gaps regarding the quantitative data related to the nexus in the Arab region. The need for scientific research to fill the knowledge gaps regarding the water-food-energy nexus is a priority issue. Universities and research institutes should be encouraged to adopt research programmes to improve understanding of the nexus in the Arab region. In this regard, quantitative information about the water requirements for energy, energy requirements for water, and water and energy requirements for food value chain should be established and stored in the common platform. Physical inter-linkage equations between water, energy and food quantitative information should also be identified.

Different scenarios of the water quantities used in energy production and energy intensities required for the water supply systems in the Arab region should be evaluated as well, using accurate and up-to-date data. Other scenarios such as water savings, increase water and energy systems efficiencies, food conservation, virtual water and other nexus policies should also be evaluated to optimise water, energy and food resources.

Finally, to perform institutional and quantitative analysis simultaneously, it is important to establish a common platform to address water, energy and food nexus in the Arab region. This platform should serve as the basis for dialogue, priority setting and policy formulation on the nexus at the regional level.

References:

- Feldman and Khademian, 2007, "The Role of the Public Manager in Inclusion: Creating Communities of Participation" *Governance 20 (2), pp 305–24.*
- Mielke E., Anadon LD., Narayanamurti V., 2010, Water Consumption of Energy Resource Extraction, Processing, and Conversion. Belfer Center for Science and International Affairs. Harvard Kennedy School, Cambridge, MA, United States.
- Rogner H.H. et. al, 2012, "Seeking CLEWS Climate, Land, Energy and Water Strategies A pilot case study in Mauritius".
- Siddiqi A. and Anadon L.D., 2011, "The water-energy nexus in Middle East and North Africa", *Energy Policy 39, pp 4529-4540*
- SEI, 2012, "Training Exercises for Integrated Water-Energy Planning: Linking WEAP and LEAP" - Stockholm Environment Institute
- U.S. - SABC, 2009, The water sector in the Kingdome of Saudi Arabia. U.S.-Saudi Arabian Buisiness Council, Vienna.

Lamia Mansour, PhD
Team Leader - Environmental Fund for Lebanon
German International Cooperation (GIZ)/Ministry of Environment/CDR

The role of industrial innovation in water resources management and its relation to the nexus sustainability

The evolution of the industrial sector in Lebanon

The industrial sector in Lebanon is an important pillar of the Lebanese economy; while latest figures show that it has contributed to around 7.2% of the country's Gross Domestic Product (GDP) in 2010, this rate was much higher in the nineties and was estimated up to 12.5% in 1997[1]. The sector had also showed a rapid growth which reached 13% in 2007; though the political uncertainty in the region has slowed industrial growth down to 3% since 2010[2].

According to the latest census conducted by the Ministry of Industry of 2010[3], a total number of 4,033 industrial establishments (establishments employing more than 5 workers) existed in Lebanon. The key industrial sectors in Lebanon are Food products and beverages,

[1] Central Administration of Statistics, 2010. Lebanese National Accounts.
[2] IMF, 2012. Lebanon Article IV
[3] MoI, 2010. The Lebanese Industrial Sector: Facts and Findings of study conducted in 2007. UNIDO, ALI

Fabricated metal products and Other non-metallic mineral products. These constitute 50% of the economic activity of the industries in the country. Other sectors are also present including the chemical sector, furniture manufacturing and electrical machinery manufacturing

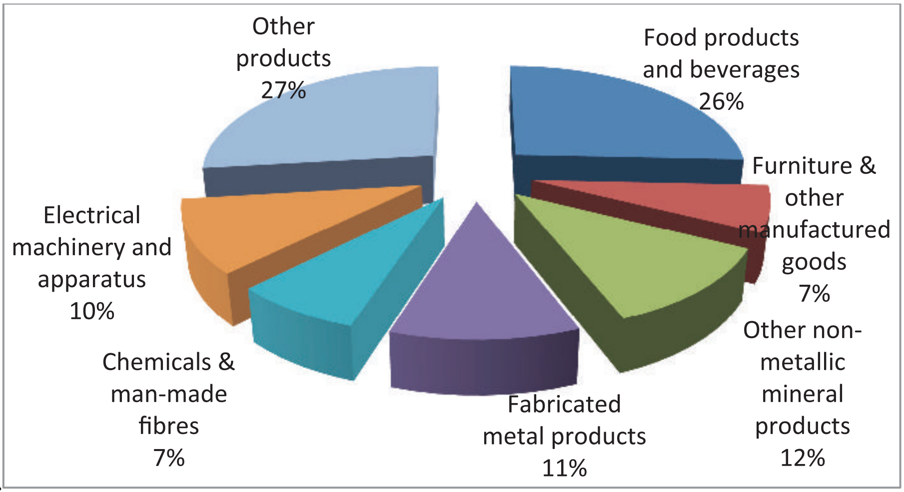


Figure 1: Distribution of Industrial Output by Economic activity

Industrial water demand and industrial wastewater

Industrial wastewater results from a relatively high waster demand at industries that is estimated to range between 150 and 163 Mm^3 per year, equivalent to around 11% of the total annual water demand[4] shown in Figure 2 below. The projected water demand by the industrial sector is expected to reach up to 16% of the total annual water demand in 2030[5]. In the industrial sector, water is mostly needed during manufacturing and its uses are mainly:

[4] National Water Sector Strategy: Supply/Demand Forecasts, DRAFT, MOEW, November 2010
5 World Bank, Water Sector: Public Expenditure Report, Draft 2009

1. Washing, cleaning and rinsing products;
2. Cooling;
3. Process uses (lubricant, solvent or reactant in a chemical reaction);
4. Transporting parts or ingredients;
5. Wet scrubbing (if any);
6. Steam generation;

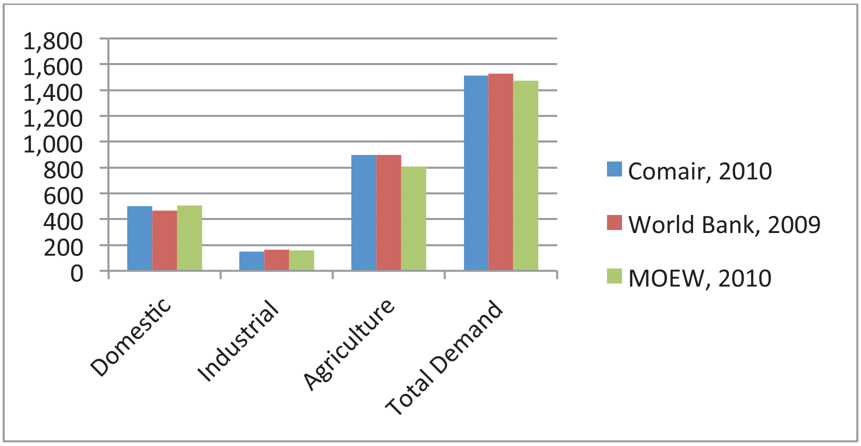


Figure 2: Estimates of current water demand (Mm^3/year)

This extensive amount of water demand especially in the key industrial sectors such as the food and beverages industries will result in the generation of large quantities of wastewater. Lebanon produces around 310 Million m^3 of wastewater; of which around 60 Million m^3 is industrial wastewater[6]. As such, around 20% of the wastewater produced in Lebanon is industrial wastewater which varies in both flow and pollution strength (depending on the different industrial processes).

In general, industrial wastewater may contain suspended, colloidal and dissolved (mineral and organic) solids. They may be either excessively acid or alkaline (depending on the process) and may contain high or low concentrations of colored matter. These wastewaters may contain inert, organic or toxic materials and possibly pathogenic

[6] MOEW, 2010. National Wastewater Sector Strategy.

bacteria. Industrial effluents could also affect the operation of planned wastewater treatment plants (WWTPs), heavy metals kill/inactivate microorganisms (if biological treatment is adopted).

Enabling environment for innovation in industrial wastewater management in Lebanon

Water use and wastewater treatment and reuse in the industrial sector constitute an important aspect of the water resources management in Lebanon and significantly affect the sustainability of the Water, Food and Energy Nexus given the importance of this sector and its reliance on the water resources.

Addressing such an issue requires policy, institutional as well as technical considerations, and the concerned institutions such as the Ministry of Environment and the Ministry of Industry have started to incorporate environmental guidelines and safeguards related to industrial wastewater management in new industrial permits.

A comprehensive analysis of the related policies and actions have been investigated under the GIZ/ Environmental Fund for Lebanon in coordination with the Ministry of Environment and the Council for Development and Reconstruction, in coordination with key national stakeholders, which provided a series of recommendations for an action plan for industrial wastewater management[7]. This action plan is presented in Figure 3 below and indicated the following priority actions to be addressed:

- Incorporate Environmental Requirements in the Permitting System
- Move from End-of-pipe to Cleaner Production
- Strengthen Environmental Monitoring and Enforcement

[7] GIZ/EFL, 2013. Policy paper and action plan for industrial wastewater treatment. MoE, CDR.

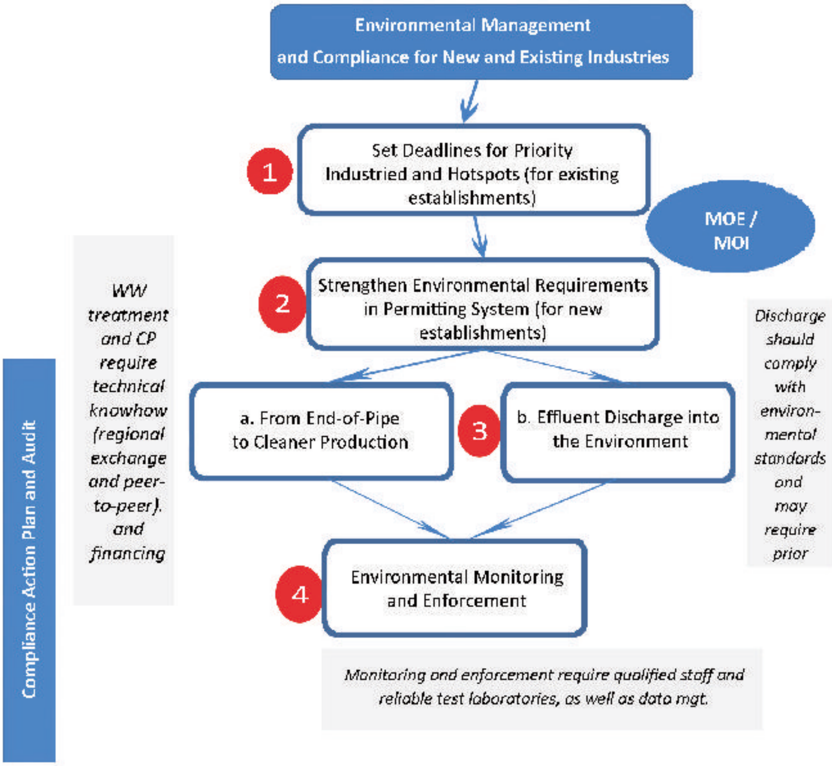


Figure 3: Proposed process for implementing the industrial action plan for Lebanon

Technical know-how and financial incentives

At the technical level, advancements in this field are hampered by the lack of in-country experience and its associated costs. The majority of industries who have adopted wastewater treatment systems have relied on foreign expertise and knowhow (Italy, Holland, USA). The Environmental Fund for Lebanon has implemented 6 pilot projects for industrial wastewater treatment in different sectors in 2011[8], these pilot projects have a great potential for knowledge transfer and cross-learning

[8] www.efl.moe.gov.lb

between industries that belong to the same industrial sector (as shown in Figure 4 below).

Another important barrier to wastewater treatment is capital investment, as well operation and maintenance. While it is true that wastewater treatment can be expensive, ample research shows that it is affordable and represents a small fraction of the total investment cost for existing or new establishments. Industries must identify opportunities for cleaner production early on and the Lebanese Government must provide incentives for the industries to pursue them.

Savings from Cleaner Production can quickly offset the cost of introducing and operating wastewater treatment systems. Cleaner Production and wastewater treatment must not be perceived as an afterthought; they should be incorporated in the project design from the outset.

Figure 4. Different industrial wastewater treatment technologies can be applied in the same industrial sector. This example from the vegetable oil industries where a closed-circuit water cooling system (photo to the left) and chemical and physical treatment (photo to the right) were adopted as needed

The future for action and linking to the Nexus

National action for promoting innovation in the industrial sector in Lebanon is a promising ground as the industrial sector is growing in

Lebanon and the enabling environment and other technical and financial requirements for action are gradually being made available.

The importance of industrial innovation in the adoption of industrial wastewater treatment in specific and other management production systems as a whole is an important factor for the sustainability of the Water, Food and Energy Nexus. The industrial sector's reliance on the water resources are expected to reach 16% of the total annual water demand in 2030, the food products and beverages sector is among the key industrial sectors in Lebanon and constitute 26 % of the economic activity of the industries, recent import trends have confirmed that the food products and beverages sector stands among the highest sector in import of industrial goods[9].

As the political implications in the region threaten the planning of a balanced development, several initiatives are spearheaded by the Lebanese Government with the support of several donors for providing and sustaining the momentum in industrial innovation through the provision of technical assistance and investment financing for industrial pollution abatement, which can provide needed support for water and wastewater management in industries in line with the recommendations of the industrial wastewater action plan as follows:

- Assist industries in finding wastewater treatment (WWT) solutions using proven technologies and know-how
- Assist industries in implementing Cleaner Production (CP) systems including water conservation with technical guidance and support
- Develop and mainstream fiscal and non-fiscal incentives to promote WWT and CP by facilitating access to technology and by alleviating O&M costs.

[9]Monthly data published by Ministry of Industry

Bilal Nsouli, PhD
Director
Lebanese Atomic Energy Commission- National Council for Scientific Research

The role of Nuclear Energy in Water-Food-Energy Nexus*

Abstract

Water-Food-Energy Nexus has become a global concern due to the climate change from global warming that has been affecting the natural resources abundance, mainly, water. Added to this is the rapid growth of the population and some technologies, even for energy production purposes, which is only making the global warming worse. Due to the mutual dependence of water and existing used energy, a serious problem, among many, of sustainability is arising. For this, the planet needs an alternate energy which could be Nuclear Energy. In this paper, nuclear energy is considered in the nexus context. Advantages, drawbacks and prerequisites for embarking a nuclear power program are presented and discussed

Keywords: nuclear energy, water-food-energy nexus, climate change, global warming

*Prepared in collaboration with Munza Assi

1. Introduction

Global warming has been increasingly posing severe dangers for natural, social and economical systems in many regions of the world. Due to its impact on the climate change, it is considered a challenging factor for the selection of the type of energy used in the Water, Energy and Food Nexus which has become a central concern to the Green Economy. Added to this factor is the continuous population growth which poses an increasing demand for energy, food and water and this will compromise the sustainable use of natural resources.

If the arising shortage is not rapidly solved, there will be high risk on people, deteriorating economic development which could end up in an irremediable environmental damage.

Nowadays, the concept of Water-Energy-Food Nexus has made a huge shift in the technological approach of how to choose the most feasible energy as a key factor to save the planet. There is no absolute safe energy, neither an ideal one, but considering the cons and the pros, the environmental as well as the economical, social, and even public impacts could lead to the correct approach of using the energy that allows managing natural resources in the most effective way possible. For this, understanding the relation between water and the production and use of energy and food is very essential.

A good example to understand this nexus is to know that nowadays the agriculture uses 70% of the world's water to irrigate only 20% of the world's lands, yet only producing 40% of all food. The energy sector withdraws 8% of all the worlds' water. So water is the key element here. Food and energy production depend on the availability of and access to water resources. Statistically, by 2030, the demand for water, energy and food is expected to increase by 30-50 %. It is also expected that in 2040, two billion people on the planet with the challenges from climate change, the pressure on water, energy and food will have increased dramatically.

So there is an urgent need to find other ways to produce energy and to deliver water where needed. The solution could be Nuclear Energy as it belongs to the range of energy sources and technologies available today which can help meet the climate–energy challenge.

Understanding this nexus and finding the right solutions for energy production could open up some opportunities, mainly:

- Increase policy coherence
- Create more with less
- Value natural infrastructure
- Accelerate access
- Reduce waste and minimize losses
- Mobilize consumer

In this respect, the Kyoto Protocol was established, to respond to the continuous efforts of the United Nations to promote safe energy use, and the United Nations Framework Convention on Climate Control,

2. Kyoto Protocol

The "Kyoto Protocol" sets binding obligations on industrialized countries to reduce the emissions of greenhouse gases.

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change, to cooperatively consider what they could do to limit average global temperature increases and the resulting climate change, and to cope with whatever impacts were, by then, inevitable.

By 1995, countries realized that emission reductions provisions in the Convention were inadequate. They launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol legally binds developed countries to emission reduction targets. The Protocol's first commitment period started in 2008 and ended in 2012. The second commitment period began on 1 January 2013 and will end in 2020.

There are now 195 Parties to the Convention and 192 Parties to the Kyoto Protocol.

Emissions trading, as set out in Article 17 of the Kyoto Protocol, allows countries that have emission units to spare - emissions permitted them but not "used" - to sell this excess capacity to countries that are over their targets.

Thus, a new commodity was created in the form of emission reductions or removals. Since carbon dioxide is the principal greenhouse gas, people speak simply of trading in carbon. Carbon is now tracked and traded like any other commodity. This is known as the "carbon market."

3. Forms of Available Energy

The available of Energy nowadays can be divided into two categories - primary and secondary.

Primary energy is energy in the form of natural resources, such as wood, coal, oil, natural gas, natural uranium, wind, hydro power, and sunlight.

Secondary energy is the more useable forms to which primary energy may be converted, such as electricity and petrol.

Primary energy can be renewable or non-renewable:

Renewable energy sources include solar, wind and wave energy, biomass (wood or crops such as sugar), geothermal energy and hydro power.

Non-renewable energy sources include the fossil fuels - coal, oil and natural gas, which together provide over 80% of our energy today, plus nuclear energy

The main concern is what does primary energy use in order to produce the secondary energy, and whether the current 80% resources are optimal and sustainable. This brings us back to the global warming issue. The current forms of energy used are affecting adversely the climate change by contributing to the global warming. Added to this, the fact that this primary energy depends, at times, on water which is consumed immensely in some practices as oil extraction, but at other times water also depends on energy., So a break in chain is necessary to save the water. Added to this the urge need to reduce CO2 emissions to stop the global warming. This leads to the conclusion that it is inevitable to replace the main forms of energy used today with the alternative of *"clean"* energy.

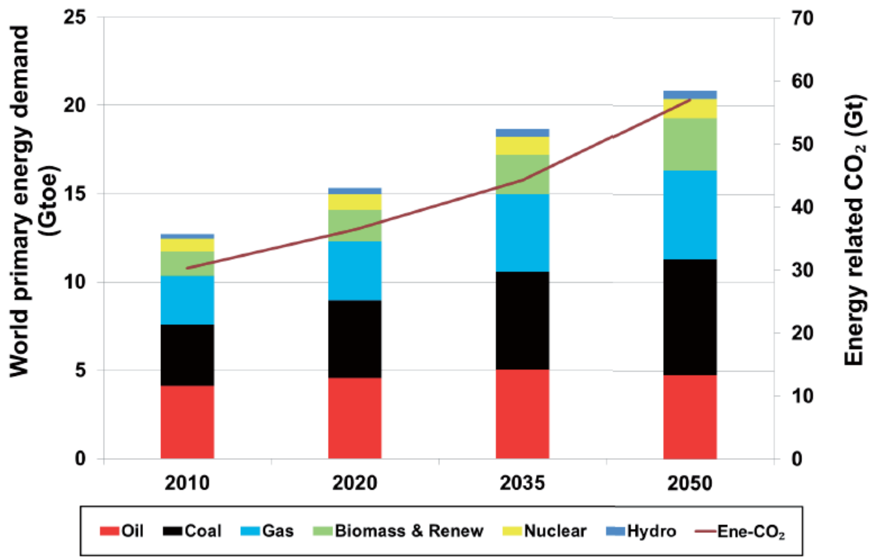


Figure1: *Global primary energy sources (left axis) and energy related CO2 emissions (right axis) in the IEA's WEO 2012 Current Policies scenario (up to 2035, Data Source:* OECD IEA, World Energy Outlook 2012, OECD/IEA, Paris (2012).

4. Energy Sustainability

Unlike the past consideration of energy sustainability which simply was defined as the availability of energy, nowadays and due to the concerns about global warming, other factors have emerged that changed this concept. These include environmental impact, management of wastes, economical burden and public acceptance. Safety has also become an issue, as well as security. So the question has become about how to define the energy needs on a sustainable basis considering the different options available and their related factors.

A very appropriate consideration could be the renewable energy, such as the solar or wind energy, because it could be obtained without any depletion of mineral resources and/or any direct air or water pollution. However, this 'free' energy is not the *ultimate* option. These renewable sources could be diffuse, intermittent, and unreliable by nature of their occurrence. This leads to the conclusion that renewable sources cannot be continuous, reliable and sustainable energy that could be a sustainable feasible solution. So Nuclear Energy could be “the” solution. According to the IAEA classification of nuclear energy scenario sustainability, different levels were defined:

Level 1. Safe, secure, economical and publicly acceptable nuclear power with security of supply – addresses conditions necessary for newcomers to deploy nuclear energy.

Level 2. Safe disposal of all nuclear wastes in a complete once-through fuel cycle with thermal reactors and with retrievable spent nuclear fuel disposal.

Level 3. Initiate recycling of used nuclear fuel to reduce wastes.

Level 4. Guarantee nuclear fuel resources for at least the next 1000 years via complete recycle of used fuel.

Level 5. Reduce radio toxicity of all wastes below natural uranium level.

If this is met, nuclear power would meet every reasonable criterion for sustainability, which is the prime concern.

Noting that nuclear energy uses natural resources, it is to the welfare of this technology, the abundance of utilized natural resources which could be coal, natural, fuel for nuclear power, uranium, hydrogen.

5. Nuclear Energy Applications

Nuclear energy is a vital component of a clean energy strategy. Currently, nuclear generation avoids the emission of over two billion ton of carbon dioxide each year.

Nuclear energy can address the competing needs for greenhouse gas emissions reduction, economic development and energy security. A wider deployment of nuclear power will reduce the cost of achieving emissions reductions, and increase the chances of meeting the climate change objectives.

Nuclear energy can be utilized in many industries and uses, as follows:

a) Electricity and Cars:

Electric vehicles and hybrid electric vehicles, which are able to be charged from mains power, have potential to greatly increase the demand for base-load power from grid systems

b) Transport and the Hydrogen Economy:

Nuclear energy is relevant to road transport and motor vehicles in three respects:

- Electromobility.
- Nuclear heat can be used for production of liquid hydrocarbon fuels from coal.

- Hydrogen for oil refining and for fuel cell vehicles may be made electrolytically, and in the future, thermochemically using high-temperature reactors.

c) Nuclear Desalination:

Potable water is in short supply in many parts of the world. Lack of it is set to become a constraint on development in some areas. Being very cost-competitive with using fossil fuels, nuclear energy is already being used for desalination, and has the potential for much greater use.

The feasibility of integrated nuclear desalination plants has been proven with over 150 reactor-years of experience, chiefly in Kazakhstan, India and Japan. Large-scale deployment of nuclear desalination on a commercial basis will depend primarily on economic factors. One obvious strategy is to use power reactors which run at full capacity, but with all the electricity applied to meeting grid load when that is high and part of it to drive pumps for RO desalination when the grid demand is low.

d) Fuel: production of H2:

The production of H_2 may become the primary use of nuclear energy and the basis for both a nuclear-H_2 renewable (solar, wind, etc.) energy economy and a nuclear-H_2 transport system. H_2 is used in fuel cells to produce the highly variable quantities of electricity needed to fill the gap between the electricity demand by the customer and the electricity generated by the rest of the electrical generating system.

e) Fertilizers:

Fertilizers are expensive and if not properly used can damage the environment. Efficient use of fertilizers is therefore of concern to both developing and developed countries. It is important that as much of the fertilizer as possible finds its way into plants and that a minimum is lost to the environment.

Fertilizers 'labeled' with a particular isotope, such as nitrogen-15 and phosphorus-32 provide a means of finding out how much is taken up by the plant and how much is lost, allowing better management of fertilizer application. Using N-15 also enables assessment of how much nitrogen is fixed from the air by soil and by root bacteria in legumes.

f) Increasing Genetic Variability:

Ionizing radiation to induce mutations in plant breeding has been used for several decades, and some 1800 crop varieties have been developed in this way. Gamma or neutron irradiation is often used in conjunction with other techniques, to produce new genetic lines of root and tuber crops, cereals and oil seed crops.

New kinds of sorghum, garlic, wheat, bananas, beans and peppers are more resistant to pests and more adaptable to harsh climatic conditions. In Mali, irradiation of sorghum and rice seeds has produced more productive and marketable varieties.

g) Insect Control

Crop losses caused by insects may amount to more than 10% of the total harvest worldwide. Chemical insecticides have for many years been the main weapon in trying to reduce these losses, but they have not always been effective. Some insects have become resistant to the chemicals used, and some insecticides leave poisonous residues on the crops. One solution has been the use of sterile insects.

The Sterile Insect Technique (SIT) involves rearing large numbers of insects then irradiating their eggs with gamma radiation before hatching, to sterilise them. The sterile males are then released in large numbers in the infested areas. When they mate with females, no offspring are produced. With repeated releases of sterilised males, the population of the insect pest in the project area is drastically reduced.

h) Food Preservation

In all parts of the world there is growing use of irradiation technology to preserve food. In over 40 countries health and safety authorities have approved irradiation of more than 60 kinds of food, ranging from spices, grains and grain products to fruit, vegetables and meat. It can replace potentially harmful chemical fumigants to eliminate insects from dried fruit and grain, legumes, and spices.

Food irradiation means that raw foods are exposed to high levels of gamma radiation which kills bacteria and other harmful organisms without affecting the nutritional value of food itself or leaving any residue. It is the only means of killing bacterial pathogens in raw and frozen food. Of course, irradiation of food does **not** make it radioactive!

Radiation is also used to sterilise food packaging. In the Netherlands, for example, milk cartons are freed from bacteria by irradiation.

i) Water Resources

Isotope hydrology techniques enable accurate tracing and measurement of the extent of underground water resources. Such techniques provide important analytical tools in the management and conservation of existing supplies of water and in the identification of new, renewable sources of water. They provide answers to questions about origin, age and distribution of groundwater, as well as the interconnections between ground and surface water and aquifer recharge systems. The results permit planning and sustainable management of these water resources.

For surface waters they can give information about leakages through dams and irrigation channels, the dynamics of lakes and reservoirs, flow rates, river discharges and sedimentation rates. Neutron probes can measure soil moisture very accurately, enabling better management of land affected by salinity, particularly in respect to irrigation.

6. Impacts of Nuclear Energy

Nuclear Energy, if peacefully well used, could provide an optimal energy alternative to the existing energy used. As the nuclear technology plays a key role in supplying the world's electricity, it is worth to note that:

- Uranium reserves and resources are plentiful
- This energy makes maximum use of low carbon technologies
- Nuclear has emissions similar to renewables, and much lower than coal and gas.

However, as any other form of energy, nuclear energy has its returns and drawbacks. Following are some points that should be considered when using nuclear energy.

a) Returns

1. More efficient energy production with the capability of installing large capacity plants
2. Energy crisis can be controlled
3. No produce of smoke or carbon dioxide, so it does not contribute to the greenhouse effect.
4. Produces huge amounts of energy from small amounts of fuel.
5. Produces small amounts of waste.
6. Nuclear power is reliable.
7. Minimal use of water in oil extraction
8. Biofuel which can be defined as a renewable source of energy, is produced from biological material or biomass, such as sugar

cane, corn, cellulose or vegetable oils. The strategic goal of biofuel is to supplement or even replace fossil fuels, the amount of which is constantly and rapidly diminishing.

9. Cost: The difference in fuel requirements, between coal fired and nuclear power stations, also affects their economics. The cost of fuel for a nuclear power station is very much less than that for an equivalent coal fired power station, usually sufficient to offset the much higher capital cost of constructing a nuclear plant. Consequently, in practical terms, electricity from nuclear reactors in many regions is competitive with electricity produced from coal, even after providing for management and disposal of radioactive wastes and the decommissioning of reactors.

b) Drawbacks

1. Although not much waste is produced, it is extremely dangerous. It must be sealed up and buried for many thousands of years to allow the radioactivity to die away. For all that time it must be kept safe from earthquakes, flooding, terrorists and everything else.
2. Nuclear power is reliable, but a lot of money has to be spent on safety - if it does go wrong, a nuclear accident can be a major disaster.

   People are increasingly concerned about this. In the 1990's nuclear power was the fastest-growing source of power in much of the world. In 2005 it was the second slowest-growing.
3. It is not easy to gain public acceptance of this technology, due to past accidents as Chernobyl. So public awareness campaigns should be well prepared.
4. Nuclear power plants use large quantities of water for steam production and for cooling, affecting fish and other aquatic life. Likewise, heavy metals and salts can build up in the water used in the nuclear power plant systems. When water is discharged

from the power plant, these pollutants can negatively affect water quality and aquatic life.

5. Risky as leakage of the nuclear fuel can be a danger
6. Nuclear Security should be carefully addressed to prevent any intentional or unintentional misuse of the utilized nuclear or other nuclear materials, which could cause serious harm. Internal and external threats to materials or facilities should be assessed.
7. Safeguards should not be compromised when dealing with any nuclear material. Restraining activities that could lead to acquisition of nuclear weapons could be the way out. If the safe use of the nuclear material in production of energy is carried out in line with the IAEA recommendations in the field, this will enhance safeguards without affecting the benefits of nuclear energy.

7. Nuclear Renaissance Era

In the new century several factors have worked together towards reviving the prospects for nuclear power. First is the realization of the scale of projected increased electricity demand worldwide, but particularly in rapidly-developing countries. Secondly is the awareness of the importance of energy security. Thirdly is the need to limit carbon emissions due to concerns about global warming.

Nuclear technology uses the energy released by splitting the atoms of certain elements. It was first developed in the 1940s., During the Second World War research initially focused on producing bombs by splitting the atoms of particular isotopes, either those of uranium or plutonium.

In the 1950s, attention turned to the peaceful purposes of nuclear fission, notably for power generation, and the first nuclear powered station started to operate then. Today, the world produces as much electricity from nuclear energy as it did from all sources combined in 1960. Civil nuclear power can now boast over 15,500 reactor years of experience, and supplies almost 11.5% of global electricity needs, from the reactors in 31 countries. In fact, through regional grids, many more than those countries use nuclear-generated power.

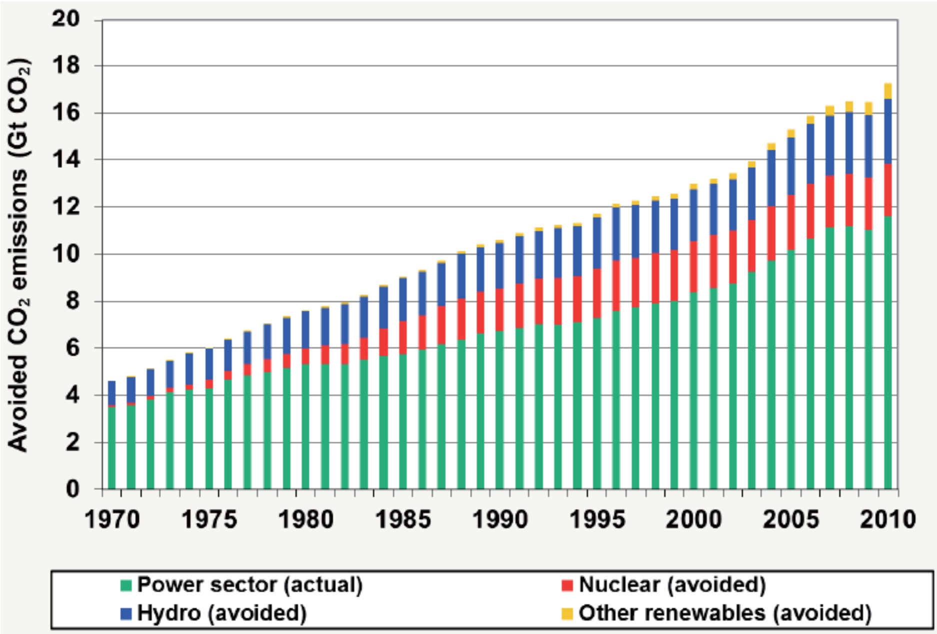


Figure 2*: Global CO2 emissions from the electricity sector and emissions avoided by using three low carbon generation technologies. Data source:* OECD IEA, Economic Outlook, Volume 2013/1, OECD, Paris (2013).

Many countries have also built research reactors to provide a source of neutron beams for scientific research and the production of medical and industrial isotopes. Currently, there are over 430 commercial nuclear power reactors operable in 31 countries, with over 370,000 MWe of total capacity. These provide over 11% of the world's electricity as continuous, reliable base-load power, without carbon dioxide emissions. There are also about 70 more reactors under construction. Furthermore, 56 countries operate a total of 240 research reactors, and a further 180 nuclear reactors power some 150 ships and submarines.

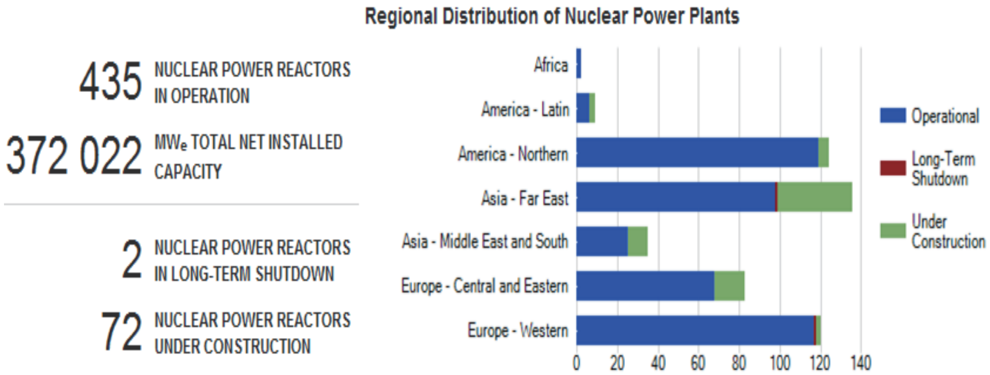


Figure 3: Current Distribution of Nuclear Power Plants. Data Source: IAEA/PRIS (2014)

Today, only eight countries are known to have a nuclear weapons capability. By contrast, 56 operate about 240 civil research reactors, over one thrid of these in developing countries.

Sixteen countries depend on nuclear power for at least a quarter of their electricity. France gets around three quarters of its power from nuclear energy, while Belgium, Czech Republic, Hungary, Slovakia, Sweden, Switzerland, Slovenia and Ukraine get one third or more; South Korea (65%) and Bulgaria and Finland normally get more than 30% of their power from nuclear energy, while in the USA, UK, Spain and Russia, almost one fifth comes from nuclear. Japan is used to relying on nuclear power for more than one quarter of its electricity and is expected to return to that level. Among the countries which do not host nuclear power plants, are Italy and Denmark. They get almost 10% of their power from nuclear energy.

Emerging Nuclear Energy Countries as of February 2014 could be distributed as follows:

- Over 45 countries are actively considering embarking on nuclear power programs. They range from sophisticated economies to developing nations.
- The front runners after Iran are UAE, Turkey, Vietnam, Belarus, Poland and possibly Jordan.

Nuclear power is under serious consideration in over 45 countries, as follows:

- In Europe: Italy, Albania, Serbia, Croatia, Portugal, Norway, Poland, Belarus, Estonia, Latvia, Ireland, Turkey
- In the Middle East and North Africa: Iran, Gulf states including UAE, Saudi Arabia, Qatar & Kuwait, Yemen, Syria, Jordan, Egypt, Tunisia, Libya, Algeria, Morocco, Sudan.
- In west, central and southern Africa: Nigeria, Ghana, Senegal, Kenya, Uganda, Namibia.
- In South America: Chile, Ecuador, Venezuela, Bolivia, Peru.
- In central and southern Asia: Azerbaijan, Georgia, Kazakhstan, Mongolia, Bangladesh, Sri Lanka
- In SE Asia: Indonesia, Philippines, Vietnam, Thailand, Malaysia, Singapore, Australia, New Zealand.
- In East Asia: North Korea.

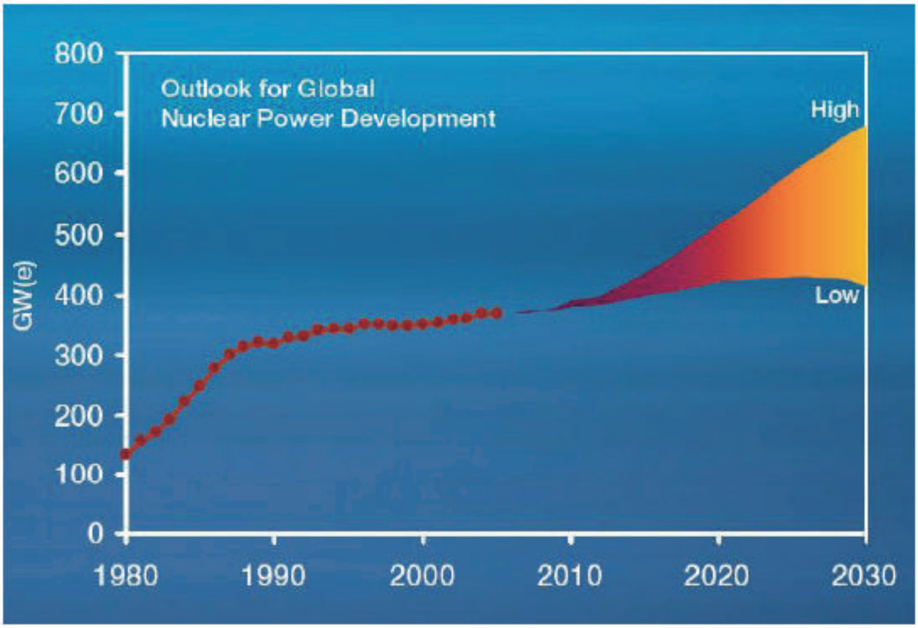


Figure 4*: IAEA Nuclear Power Outlook (in Gigawatt(GW)). Data Source: IAEA (2012)*

The major programs in some of these countries are as follows:

- Power reactors under construction: UAE, Belarus (Iran reactor has started up and been grid-connected)
- Contracts signed, also legal and regulatory infrastructure being well-developed: Lithuania, Turkey.
- Committed plans, also legal and regulatory infrastructure being developed: Vietnam, Jordan, Poland, Bangladesh.
- Well-developed plans but commitment pending: Thailand, Indonesia, Egypt, Kazakhstan, Saudi Arabia, Chile; commitment stalled: Italy.
- Developing plans: Nigeria, Malaysia, Morocco, Kuwait.
- Discussion as serious policy option: Namibia, Kenya, Mongolia, Philippines, Singapore, Albania, Serbia, Croatia, Estonia & Latvia, Libya, Algeria, Azerbaijan, Sri Lanka, Tunisia, Syria, Qatar, Sudan, Venezuela, Bolivia, Peru.
- Officially not a policy option at present: Australia, New Zealand, Portugal, Norway, Ireland, Kuwait.

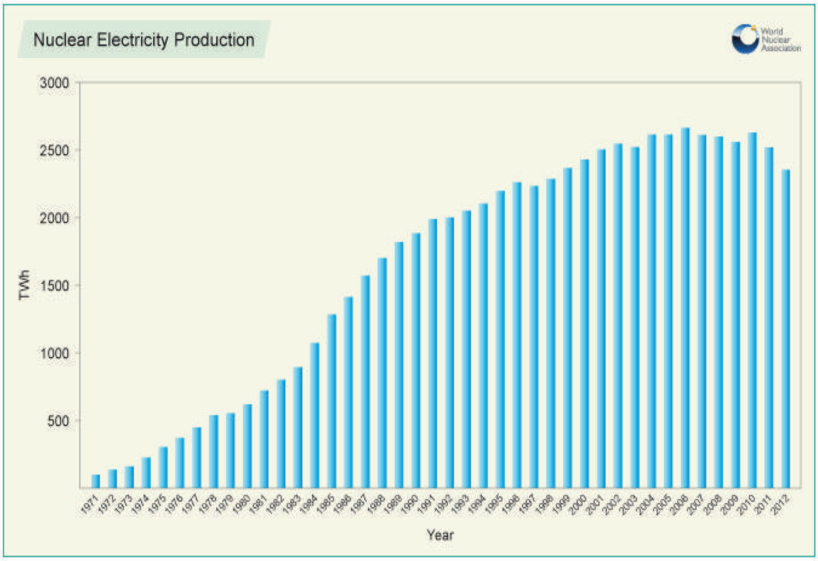


Figure 5: *Nuclear Electricity Production in* terawatt-hours (*TWh*) distribution over the years worldwide. Data Source: World Nuclear Organization

The IAEA has set out a phased 'milestone' approach to establishing nuclear power capacity in new countries, applying it to 19 issues. In broad outline (milestones underlined), the three phase approach is:

- Pre-project phase 1 (1-3 years) leading to knowledgeable commitment to a nuclear power program, resulting in the set up of a Nuclear Power Program Implementing Organisation (NEPIO). This deals with the program, not the particular projects after phase 2.
- Project decision-making phase 2 (3-7 years) involving preparatory work after the decision is made and up to inviting bids, with the regulatory body being established. In phase 2 the government role progressively gives way to that of the regulatory body and the owner-operator.
- Construction phase 3 (7-10 years) with regulatory body operational, up to commissioning and operation.

8. Nuclear Energy in Some Arab Countries:

a) Saudi Arabia

Saudi Arabia is the main electricity producer and consumer in the Gulf States, with 217 TWh production in 2009, fairly evenly split between oil and gas. Capacity is over 30 GWe. Demand is growing 8% per year, and peak demand is expected to be 60 GWe by 2020. Saudi Arabia is unique in the region in having 60 Hz grid frequency, which severely limits the potential for grid interconnections.

In August 2009, KSA announced that it was considering a nuclear power program, and in April 2010 a royal decree stated: "The development of atomic energy is essential to meet the Kingdom's growing requirements for energy to generate electricity, produce desalinated water and reduce reliance on depleting hydrocarbon resources."

In April 2013 KA-CARE projected 18 GWe of nuclear capacity by 2032 of total 123 GWe, with 16 GWe solar PV, 25 GWe solar CSP (to provide for heat storage), and 4 GWe from geothermal, wind and waste. About half the capacity in 2032 would still be hydrocarbon, with one third solar, following an investment of some $108 billion. In addition 9 GWe of wind capacity would be used for desalination.

b) United Arab Emirates

UAE established a Nuclear Energy Program Implementation Organization which has set up the Emirates Nuclear Energy Corporation (ENEC) as a public entity. Initially funded with $100 million, it is to evaluate and implement nuclear power plans within UAE.

In October 2009 the Federal Law Regarding the Peaceful Uses of Nuclear Energy was signed into effect, providing for development of a system for licensing and control of nuclear material, as well as establishing the independent Federal Authority of Nuclear Regulation to oversee the whole UAE nuclear energy sector, and appointing the regulator's board, headed by a senior US regulator. The law also makes it illegal to develop, construct or operate uranium enrichment, or spend fuel processing facilities within the country's borders.

By 2020 UAE hopes to have four 1400 MWe nuclear plants running and producing electricity at a quarter the cost of that from gas. ENEC has appointd the global full-service program management, engineering, construction and operations firm C2HM Hill to manage the UAE's plans for bringing nuclear power to the country.

The site selected is at Barakah, on the coast 53 km west of Ruwais, a little closer to Qatar than to Abu Dhabi city. ENEC lodged a full construction licence application for units 1 & 2 in 2012, and started construction of unit 1, and unit 2. Operations in unit 1 and unit 2 are expected a year later. Commercial operation is envisaged in 2017 and 2018 respectively, followed by 2019 and 2020 for units 3 & 4.

However, apart from Abu Dhabi's Barakah plant, Dubai is considering its own nuclear power possibilities,. In 2009, a Supreme Council of Energy, as an independent legal entity, was set up. Its task is to oversee all matters relating to Dubai's energy sector. This includes possible use of nuclear energy for electricity and desalination plants.

The USA and South Korea signed bilateral nuclear energy cooperation agreements with the UAE in January and June 2009 respectively. The UK and Japan have signed Memoranda of Understanding on nuclear energy cooperation with UAE. France has a nuclear cooperation agreement with UAE and has discussed nuclear energy development with Saudi Arabia, offering Atomic Energy Commission (CAE) assistance. The USA has signed memoranda of understanding regarding nuclear cooperation with Saudi Arabia and Bahrain.

c) Jordan

Jordan imports over 95% of its energy needs, at a cost of about one fifth of its GDP. In 2009, Jordan generated 14.3 Billion kWh, mostly from natural gas, and imported 0.4 billion kWh of electricity for its six million people. In 2012 its electricity was 25% from natural gas imported (unreliably) from Egypt, 32% from heavy fuel oil, 32% from diesel, and 11% was imported. It has 2400 MWe of generating capacity and expects to need 3600 MWe by 2015, 5000 MWe by 2020 and 8000 MWe by 2030, for it expects doubled electricity consumption. Per capita electricity consumption is about 2000 kWh/yr. Jordan has regional grid connection of 500 MWe with Egypt and 300 MWe with Syria.This will both increase energy security and provide justification for larger nuclear units.

Jordan has also a "water deficit" of about 600 million cubic metres per year (1500 demand, 900 supply). Its 2007 national energy strategy envisages, by 2020, 29% of primary energy from natural gas, 14% from oil shale, 10% from renewables and 6% from nuclear. Jordan has regional grid connection of 500 MWe with Egypt, 300 MWe with Syria, and it is increasing links with Saudi Arabia, and Palestine. This will both increase energy security and provide justification for larger nuclear units.

Jordan's Committee for Nuclear Strategy, set up in 2007, set out a program for nuclear power to provide 30% of electricity by 2030, and to provide for exports. The nuclear law was modified in 2007 to establish the Jordan Atomic Energy Commission (JAEC) and the Jordan Nuclear Regulatory Commission (JNRC), including radiation protection and environmental roles.

JAEC expects to start building a 750-1200 MWe nuclear power unit in 2013 for operation by 2020 and a second one for operation by 2025.

As for Uranium, the country claims low-cost uranium resources of 140,000 tU plus another 59,000 tU in phosphate deposits. A feasibility study on recovering uranium as a by-product of phosphate production is under way.

Jordan has signed nuclear cooperation agreements with France, Canada, UK and Russia, in respect to both power and desalination, and is seeking help from the IAEA.

d) Egypt

Egypt produced 115 billion kWh gross in 2006 from 18 GWe of plant, giving per capita consumption of 1350 kWh/yr, though this had risen to 1910 kWh/yr at the end of 2012. In 2006, 72% of electricity came from gas, 16% from oil and 11% from hydro. Demand growth is about 7% pa. Gas resources are expected to be severely depleted in 20 years. In 2011-12 generating capacity was 25.1 GWe and the projected capacity in 2021-22 is 43.7 GWe.

Egypt set up its Atomic Energy Commission in 1955, to become in the following year, the Atomic Energy Authority, and to be responsible for licensing and regulation.

On the basis of a feasibility study, conducted in October 2006 for a cogeneration plant for electricity and potable water at El-Dabaa, the Minister for Energy announced that a 1000 MWe reactor would be built there by 2015. The US$ 1.5 to 2 billion project would be open to foreign participation. The ministry declared that Egypt aimed to begin generating nuclear electricity in 2017 at one of five possible sites.

Early in 2010 the proposal expanded to four plants by 2025, the first being on line in 2019 or 2020. In March 2010 a legislative framework to regulate nuclear installations and activities in order to ensure the protection of facilities, individuals and property was signed into law.

As well as addressing power supplies, the NPPA expects to have four nuclear desalination plants operating by 2025.

9. Remarks

It is worth noting that an appropriate water, energy and food nexus approach should be urgently selected and implemented, under a clear policy which abides by the following guidelines, as recommended by the Bonn2011 Nexus Conference:

- Set mechanisms for policy coherence at the decision making level;
- Enhance understanding the interlinkages between water, energy and food and developing response strategies and investment portfolios within and across sectors;
- Set the right incentives, review existing subsidies and remove those which are harmful to water, energy and food security.
- Support mechanisms for vulnerable groups
- Establish financing arrangements to encourage and reward innovations or replications of promising initiatives and solutions of mutually beneficial character for the three sectors, which adequately value ecosystem services;

- Prepare medium to long-term Nexus-Strategies based on Water, Energy and Food "Outlooks" setting measurable targets;
- Develop systematically the capacities of all actors, in a way to take a nexus perspective in decision making and planning,
- Educate the young to think along the mind-set of interdisciplinarity.

Nuclear energy is a reliable sustainable source of energy that could help enhance the energy, water and food nexus. It could solve the loop of the dependence of water on energy and the dependence of energy on water, as being used currently, knowing up that nuclear energy does not need water, as a main source, to function.

Nevertheless, launching a nuclear power program is a major undertaking that requires careful planning, preparation and investment in time and resources. It requires a prior establishment of a special infrastructure that covers a wide range of issues starting from the legal basis and ending in the decommissioning plan. A nuclear program extends about 100 years while a feasibility study at the initial stages, is a must to realize all stages, from planning (~3 years), to establishment (~20 years), to operation (~50 years and more), and decommissioning (~10 years). This study should consider the establishment of the necessary legal and regulatory background which is the basis and prerequisite of any similar activity, as recommended by the IAEA. Several technical issues have to be well examined, especially the physical construction of the facilities for the delivery of electricity, the site and supporting facilities for handling radioactive waste. Human resources development is also a vital issue to serve at every stage. Along with obligatory safety issues to be considered, a fair ground should be supplied to provide security and safeguards. There are several international instruments, binding and non binding, that must, where necessary, be reviewed and met before considering the final decision to go nuclear. These are listed below:

a) **Safeguards**

- Structure and Content of Agreements Between the Agency and States - Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons (INFCIRC/153 Corrected)
- Model Protocol Additional to the Agreement(s) Between State(s) and the Agency for the Application of Safeguards — INFCIRC/540 Corrected.

b) **Nuclear Safety**

- Convention on Early Notification of a Nuclear Accident (INFCIRC/335);
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (INFCIRC/336);
- Convention on Nuclear Safety (INFCIRC/449);
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546).
- Nuclear Security
- Convention on the Physical Protection of Nuclear Material (INFCIR/274);
- Amendment to the Convention of the Physical Protection of Nuclear Material (GOV/INF/2005/10-GC(49)/INF/6).

c) **Nuclear Liability**

- Vienna Convention on Civil Liability for Nuclear Damage (INFCIRC/500);
- Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (INFCIRC/402);
- Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage (INFCIRC/566);

- Convention on Supplementary Compensation for Nuclear Damage (INFCIRC/567).

10. References

- International Atomic Energy Agency (2013), CLIMATE CHANGE AND NUCLEAR POWER
- Apergis, N., Payne, J. E. (2010), A panel study of nuclear energy consumption and economic growth. Energy Economics
- International Atomic Energy Agency (2009), Status and Trends of Nuclear Technologies — A Report of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), IAEA-TECDOC-1622
- WORLD BANK, Global Economic Prospects (2013), World Bank, Washington DC
- Clarence Hardy (1999), Atomic Rise and Fall
- International Atomic Energy Agency (2012), Nuclear Technology Review 2012, IAEA, Vienna
- Verbruggen, A. (2008), Renewable and nuclear power: A common future?. Energy Policy
- Spencer Weart (1997), Radiation in Perspective. Harvard UP, OECD NEA,.
- European Commission (2011), Roadmap for moving to a low-carbon economy in 2050. Available on line [http://ec.europa.eu/clima/documentation/roadmap/docs/com_2011_112_en.pdf] (June 23rd, 2011)
- OECD Nuclear Energy Agency (2000), Nuclear Energy in a Sustainable Development Perspective
- OECD Nuclear Energy Agency(2001), Trends in the Nuclear Fuel Cycle: Economic, Environmental and Social Aspects
- Judith Perera (1988), Nuclear Fear
- OECD Nuclear Energy Agency (1999), Long-term management of radioactive waste – Ethics and the environment, C. Pescatore, NEA Newsletter, Spring (1999), Volume 17, No. 1,
- World Nuclear Organization (2014), The Many Uses of Nuclear Technology, Information Library
- International Atomic Energy Agency (IAEA) (September 2010), Report on International Status and Prospects of Nuclear Power
- Jonathan Schell(2007), The Seventh Decade: The New Shape of Nuclear Danger
- UN Conference on Sustainable Development “Rio2012”.
- UN The Warsaw Climate Change Conference 2013

- 3rd Forum on the Climate – Energy Security Nexus: Electricity Sector Resilience, Friday, 25 October 2013, International Energy Agency, Paris
- N. Müllner, W. Liebert, W. Kromp, S. Sholly, G. Kastchiev, K. Gufler, N. Arnold, W. Renneberg (2013), The future role of nuclear power in Europe, University of Natural Resources and Life Sciences, Vienna
- OECD International Energy Agency, World Energy Outlook 2012, OECD/IEA, Paris (2012).
- OECD International Energy Agency, Economic Outlook, Volume 2013/1,OECD, Paris (2013).
- OECD International Energy Agency AGENCy, World Energy Balances, IEA World Energy Statistics and Balances (2013)

الجلسة الختامية والتوصيات

Closing Session & Recommendations

السيدة رلى مجدلاني

مديرة إدارة التنمية المستدامة والإنتاجية
اللجنة الاقتصادية والاجتماعية لغربي آسيا (الاسكوا)

أشكر مؤسسة رفيق الحريري ممثلة بالمديرة العامة السيدة سلوى السنيورة بعاصيري على الجهد المبذول للإعداد والتحضير لهذا المؤتمر.

وأشكر الخبراء على هذه العروض والمداخلات القيمة التي تناولت مختلف جوانب الترابط، الفنية والاجتماعية والاقتصادية والتنموية. إنه أمر مميز حقاً أن يجتمع في هذا المؤتمر هذه الكوكبة من الخبراء في الاختصاصات المختلفة.

كما أشكر الجميع على حضورهم ومشاركتهم في هذا المؤتمر، واسمحوا لي أن أنوه بالمناقشات البناءة التي تمت والتي لا شك أغنت المعرفة بكافة أبعاد العلاقة الترابطية بين المياه والغذاء والطاقة والتي تضمنت مواضيع لها تأثير مباشر على التنمية الاجتماعية والاقتصادية لمجتمعنا وعلى تحديد الطرق الفضلى للمحافظة على مواردنا وعلى تعزيز الامن الغذائي.

واسمحوا لي أن أوجز أبرز العناوين التي أثيرت في هذا المؤتمر:

- تطوير الأسواق المالية في لبنان وتأثير ذلك على تعزيز الأمن الغذائي
- تأثير نوعية وكمية المياه على الزراعة واستخدام الأراضي
- المتطلبات الاجتماعية والاقتصادية للترابط بين المياه الطاقة والغذاء
- الوضع الحالي للموارد المائية في لبنان وكيف تتأثر مع تغير المناخ، وكيف يؤثر تغير المناخ

على استدامة الترابط بين المياه الطاقة والغذاء

- كيف يمكن تطبيق نهج شامل لتخطيط المياه والطاقة والغذاء على نطاق إقليمي
- ما هو دور الابتكار الصناعي في مجال الموارد المائية في استدامة ترابط المياه والطاقة والغذاء
- إلى أي مدى تسهم الطاقة النووية، كإحدى خيارات مصادر الطاقة الجديدة، في تحسين واقع الأمن الغذائي والمياه
- الآثار السياسية على الأمن المائي والأمن الغذائي في لبنان والشرق الأوسط
- دور الحفاظ على الموارد في تعزيز استدامة الترابط

إنه لمن نافل القول أن كافة المواضيع التي أثيرت ونوقشت في هذا المؤتمر تتطلب متابعة وتنسيق بين مختلف أصحاب الاختصاص من جهة، وبين الجهات المدنية والحكومية المعنية بهذا الموضوع من جهة أخرى. لذا سوف نتابع التعاون مع مؤسسة رفيق الحريري ومع كافة الجهات المعنية للدفع باتجاه تطوير القاعدة المعرفية، الخاصة بموضوع الترابط، إلى الأمام للوصول إلى أفضل السياسات الواجب اتباعها للحفاظ على مواردنا وتنمية مجتمعنا.

التوصيات

وفي ختام هذا المؤتمر، اتفق المجتمعون على التوصيات الآتية:

- تشكيل لجنة متابعة تتكون من الخبراء المشاركين في هذا المؤتمر مهمتها متابعة موضوع الترابط بين المياه والغذاء والطاقة على الصعيد الوطني اللبناني وتقديم الاقتراحات التي من شأنها الدفع باتجاه تطوير القاعدة المعرفية الخاصة بموضوع الترابط.

- متابعة الخطوات اللاحقة بهذا الخصوص بناء على اقتراحات اللجنة المذكورة أعلاه واتخاذ القرارات المناسبة بهذا الخصوص

Ms. Roula Majdalani
Director
Sustainable Development and Productivity Division, Escwa

I would like to thank the Rafik Hariri Foundation, represented by the Director General Ms. Salwa Siniora Baassiri, for the efforts made to organize this conference.

I thank the experts as well for their invaluable presentations and interventions, which addressed the subject of the Nexus from its various perspectives; the technical, social, economic and developmental. Actually it is distinctive to see this conference gather such leading experts in various disciplines.

I also thank the audience for their presence and their participation in the constructive discussions which I highly commend. They have, no doubt, enriched our awareness and knowledge with regards to the various dimensions of the Water, Food and Energy Nexus, knowing that the experts' interventions have tackled issues of direct impact on the social and economic development of our society, and have addressed the optimal means to conserve our resources and enhance food security.

May I however give a snapshot of the main issues that were raised in this conference:

- The development of financial markets in Lebanon and their impact on the enhancement of food security
- The impact of both the quality and quantity of water on agriculture and land usage
- The social and economic requisites of the Water, Food and Energy Nexus
- The current state of water resources in Lebanon and the way they are being affected by climate change. Also the effect of climate change on the sustainability of the Water, Food and Energy Nexus
- The way to apply a comprehensive approach to Water, Food and Energy Nexus on a regional scale
- The role of industrial innovation in the field of water resources towards the sustainability of Water, Food and Energy Nexus
- The extent to which nuclear energy, as one of the new energy sources, could contribute to improve the status of food security and water
- The political implications on water and food security, in Lebanon and the Middle East
- The role of resources conservation in enhancing the sustainability of the Nexus

It goes without saying that the topics raised and discussed in the conference sessions need to be followed-up and coordinated, both by the experts on one side and the concerned societal and governmental agents on the other side. We at ESCWA will continue to cooperate with the Rafik Hariri Foundation and all other stakeholders with the objective of promoting further still the knowledge base on the Nexus and devising the best policies to be adopted in order to preserve our resources and develop our society.

Recommendations

Upon concluding their deliberation, the participants agreed to the following recommendations:

1- To designate a follow-up committee from amongst the experts who participated in this conference, having as a task to attend to the Water Food and Energy Nexus, at the Lebanese national level in Lebanon, and to come up with suggestions that may develop the knowledge base of the Nexus
2- To follow- up on the subsequent recommendations to be presented by the aforementioned committee and take the appropriate decisions in this regard

تؤكد دراسات علمية حديثة أن ما يشهده عالمنا من تسارع في تردي البيئة، وتغير غير مرتقب في المناخ، وتزايد في النمو السكاني، وحدة في الأزمات الاقتصادية في مختلف البلدان وفي العالم، بات يهدد سلامة الإنسان وأمن المجتمع واستقراره، ويرتب ضغوطا غير مسبوقة على مخزون الموارد الطبيعية، بحيث أصبح من الضروري معالجة تلك الضغوط وإدارتها بنهج جديد مختلف.
وإزاء علاقة الترابط الوثيق بين قطاعات أساسية من الموارد الطبيعية، ولا سيما بين المياه والغذاء والطاقة، أصبحت الحاجة ملحة لإجراء دراسات معمقة تتناول الطبيعة المتعددة الجانب للترابط، بعيدا عن النهج المجتزأ أو الأحادي، وذلك بحثا عن سبل ناجعة لمواجهة التحديات الضخمة تلك.

الترابط بين المياه والغذاء والطاقة عنوان لمؤتمر هو خطوة في هذا الاتجاه، تهدف إلى إفساح المجال للحوار حول التعمق في فهم طبيعة الترابط بين تلك الموارد، ورسم سلسلة مبادرات، يمكن الانطلاق منها لصنع سياسات ووضع خطط استراتيجية لإدارة الموارد، تحقيقا لهدف التنمية المستدامة.

Recent scientific studies indicate that our world is witnessing increasing environmental deterioration, unpredictable climate changes, galloping population growth, and severe global and country-level economic crisis. Together, these factors carry a real threat to human safety, social security and political stability. They also cause unprecedented pressures on natural resources, mainly water, food and energy, necessitating an innovative approach in the handling and management of these resources.
The interlinkages and synergies across the water, food and energy sectors form a multidimensional nexus that should be explored in depth, with a view to finding effective ways to tackle the related daunting challenges.

The conference on Water, Food and Energy Nexus is meant to serve as a platform to discuss an integrated approach to the nexus. The objective is to devise a set of initiatives to design policies and develop strategic plans for the management of resources towards sustainable development.

ISBN 978-9953-0-3023-4

9 789953 030234 >