NEXUS

Higher Council for Science and Technology
المجلس الأعلى للعُلوم والتكنولوجيا

Higher Council for Science and Technology

WEFE Nexus Conference

الذكاء الاصطناعي:
حلقة الوصل في منظومة المياه والطاقة والغذاء والبيئة

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حضرة صاحب السمو الملكي

الأمير الحسن بن طلال المعظم

رئيس المجلس الأعلى للعلوم والتكنولوجيا

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بلدهم مقراً وليس ممراً فقط، وهذا من شأنه أن يخدم الشعب الأفغاني. وينطبق الأمر نفسه اليوم على العديد من البلدان مثل السودان واليمن. فكيف يمكننا تحقيق الاستقرار في منطقتنا، من دون اتخاذ القرارات المبنية على البيانات؟

يمكن للذكاء الصناعي إحداث ثورة في طريقة توليد البيانات وتحليلها والاستفادة منها، ومن الخوارزميات في WEFE Nexus لتوقع احتياجات المياه، بناء على أنماط الطقس، ومستويات رطوبة التربة، ومتطلبات المحاصيل، ويمكن للمتخصصين تحليل مجموعة من المعلومات واسعة النطاق لتحديد الأنماط، إلا أننا لا يمكننا تحسين عمليات صنع القرار، إلا إذا فهمنا أن الهدف الرئيس بالنسبة لنا هو التنمية وكرامة الإنسان. وأذكّر هنا بأهمية الحقائق المطلقة، وبناء قاعدة بيانات شاملة، حيث أسسنا في الجمعية العلمية الملكية منذ العام ١٩٧٤ نواة لتلك القاعدة في خدمة مسيرة تكريم الإنسان، وتعزيزًا لمقولة الحسين طيب الله ثراه «الإنسان أغلى ما نملك»، وأضيف أن الإنسان المعطاء هو الذي نبحث عنه، ونحتاجه دائما.

في مجال الموارد الطبيعية والتفويض والتمكين، أتحدث عن البحر الميت، ليس كمشكلة أردنية أو فلسطينية، بل كظاهرة دولية عابرة للحدود. إن الحقائق الجيوفيزيائية لهذه الهدية الطبيعية المهمة تتطلب اهتماما عظيما من لجنة دولية. كما أتحدث عن الوادي المتصدّع العظيم، أو صدع البحر الأحمر الذي يمتد من أنطاليا إلى شرق أفريقيا إلى مدغشقر مرورًا بالأردن.

وعودة إلى اللجنة الدولية التي طورتها مجتمعات الفحم والصلب؛ فإنني أتساءل: ألا يمكننا أن نفكر في إنشاء لجنة دولية ذات غرض صريح يتمثل في تطوير العدالة الاجتماعية؟ ثمّ ألا يمكننا إيجاد نوع من المشتركات بين النخب السياسية والنخب الاقتصادية من جهة، وبين الشعب من جهة أخرى؟ هل نستطيع بناء علاقة تكاملية بين النخب السياسية والنخب الاقتصادية، وبين الناس؟ والمواطنون يتوقّعون، بالتأكيد، تبسيط هذه المفاهيم التقنية، لتصل إليهم.

ذكرت في بداية حديثي إشارة إلى التعليم الجامعيّ، بوحي من حديث سعادة السفير، فهل يمكننا الوصول إلى ممارسات الأعمال المستدامة؟ أم أننا نقدّم أعذارًا للحكومات؟ هل يطلب القطاع الخاص أمرا، أو أمرين، أو ثلاثة من الحكومة في غياب التنسيق والتكامل بين المعنيين؟ وأهم ما في المعادلة هو الإنسان. الإنسان الذي نطمح أن يتحول من تابع إلى مواطن، أي إلى شريك. آن الاوان لتمكين الإنسان، وتفويضه في بلداننا للانتقال به من التبعية إلى المواطنة، وأعتقد أن هذا الهدف يحتاج إلى تطوير الكفاءة والإبداع، ويتعلق الأمر هنا بتيسير استخدام WEFE Nexus كأداة فاعلة لتحديد الموارد البشرية وتحسين مشاركتها، والتشارك بها، في خدمة الصالح العام، وفي تطوير المشروعات الإبداعية الوطنية ثم الإقليمية. فهل نستطيع أن نجعل من المجتمعات المحلية عنصرًا أساسيا في مفهومنا لتطوير الحاكمية الرشيدة من القاعدة إلى القمة؟ وهل يمكننا تطوير الموارد المحليّة من خلال المساهمة في إصلاح قمة الهرم المجتمعي؟ إن الرأسمالية كما وصفها جوزيف ستيكليتس لا تنجح، فنحن نتطلّع إلى الرأسمالية التقدمية، وبخاصة أن رأس المال الأكثر أهمية لدينا هو رأس المال البشري، فكيف نوظفه، ونوظّف الموارد كلّها لخدمته بصورة متكاملة؟

وختاما، فإنّ ما ينبغي لنا أن نركز عليه في جلسات اليوم، وغدًا في الجلسة الختامية، هو التأكد من صوابيّة التوصيات التي تصلون إليها، وقابليتها للتنفيذ.

وشكرًا لحسن استماعكم

توجيهات راعي المؤتمر
صاحب السمو الملكي الأمير الحسن بن طلال المعظّم
رئيس المجلس الأعلى للعلوم والتكنولوجيا

أسلّم عليكم، وأسعد بحضوركم أيها الأحبّة، وبعد،

فأودّ بداية أن أشكر سعادة السفير الألماني الدكتور مولتكه على إشارته إلى جوهر المشكلة، وهي الحاجة إلى تشكيل مجموعات من المختصين «متعددي التخصصات» في إطار دعم الوكالة الألمانية للتعاون الدوليّ GIZ لرابطة المياه، والطاقة، وإدارة النفايات، والتوظيف، والتدريب المهني، والتعليم، والحوكمة، والمجتمعات، والتداخل والتكامل بين النظم التطبيقية.

ولا بدّ لنا من أن نضع نصب أعيننا دوما الأهمّيّة البالغة لعملنا معا، بروح الفريق في المستقبل. إنّ حوكمة قطاعات المياه والطاقة والبيئة، هي الغاية التي تمكّننا من بلوغ غاياتنا، وتجعلنا قادرين على مواجهة التحدّيات، ولا سيّما التحدي الذي طرحه سعادة السفير أمامنا اليوم، ويدور حول كيفيّة تحفيز جامعاتنا على نشر الوعي بأهمية تضافر جهود أشخاص من تخصصات متعدّدة ومختلفة، مع تحفيز آليّات الحوكمة الرشيدة، والوعي بأهمية التكامل بين القطاعات المعرفيّة والعمليّة المختلفة.

في الحقيقة، الشراكة ليست بيننا وبين الوكالة الألمانية للتعاون الدوليّ، ينبثق من المفهوم الذي بدأ في الغرب، عندما تمّ تشكيل المجتمع الأوروبي للفحم والصلب ECSC في العام ١٩٥١. وفي تلك المرحلة قدّمنا خطة جونستون في وادي الأردن، لكن غياب النهج متعدد التخصصات منع الحوكمة الجيدة من التأثير في القطاعات الحيوية التي كان يمكن أن يفضي عملها إلى تأسيس سوق مشتركة، كما هي الحال في الاتحاد الأوروبي.

كان التكامل الإقليمي للموارد، في الحالة الأوروبية، متعلّقا بالفحم والسلع، بينما يتعلّق، في إقليمنا، بتكامل قطاعات المياه، والطاقة، والغذاء، والنظام البيئي. والحوكمة الرشيدة هي جزء من الرؤية الأساسية للمشرق، ولمنع المنطقة من الانجرار إلى مزيد من التفتّت بعد سايكس – بيكو.

ينصّ البند ١٧ من الأهداف التنموية المستدامة للأمم المتحدة على الشراكة Partnership ، ويحتّم ذلك علينا أن نبدأ بترتيب بيتنا الداخلي موضوعياً، لنصل إلى تلك الشراكة المنشودة؛ وهنا أتحدث عن الاستقلال المتكافل Intra Independence ، بمعنى أن يحافظ القطاع العلمي على استقلاله للمضيّ في الدراسات العلميّة، وكذلك الأمر بالنسبة للقطاع التنفيذيّ، أو الزراعيّ، أو المائيّ، أو البيئيّ، أو قطاع الطاقة، أي أن نحافظ على تلك العناوين المستقلّة، وفي الوقت ذاته أن نجعلها تعمل مجتمعة من أجل ذلك التكافل والتكامل المطلوبين، من دون النيل من هوية بعضنا البعض. على سبيل المثال، مبادرة وادي الأردن من قبل الحكومة الأردنية، تهتمّ بجزء من حدود وادي الأردن أو الاخدود الإفريقي العظيم، وهي مبادرة عملية متداخلة النظم، وينطبق هذا التداخل على سلطة منطقة العقبة ASEZA التي تعمل اليوم في منطقة أمامية مهمة جدًا.

إن قضايا الطاقة والزراعة والمياه تتجاوز الوزارات نفسها، وهي في صميم تداخل النظم. وهنا أودّ التذكير مرة أخرى بأهمية تطوير البنية الأساسية المشتركة، كما في المجتمع الأوروبي للفحم والصلب، حيث تشاركت جميع المنشآت، على مستوى وجهات النظر، عبر الحدود والدول.

وقد آمنت دائمًا بفكرة مشاركة البنية الأساسية فيما يتعلق ببلاد الشام، ولدينا ثلاث مناطق تنموية نتحدث عنها: مجلس التعاون الخليجي، والمملكة العربية السعودية، وبلاد الشام. وهنا أستذكر تجربة أفغانستان فيما يخصّ سمات شراكة في التنمية، ولنأخذ مشاريع المياه مثلاً، ونظرتهم إليها، مما يجعل

الكلمة الافتتاحية

الأستاذ الدكتور مشهور الرفاعي

الأميـن العام

المجلس الأعلى للعلوم والتكنولوجيا

سيدي صاحب السمو الملكي، الحضور الكرام

سيناقش مؤتمرنا السياسات المُتعلقة بقطاعات الـ(WEFE)، ويتضمّن برنامج المؤتمر جلسة حوارية تحضرُها نخبة من صانعي القرار، والخبراء المحليين والدوليين، لإقرار التوصيات، واقتراح أولويات البحث العلمي في هذه القطاعات المهمة.

ونتطلع من خلال المؤتمر إلى تعزيز التعاون بين قطاعات الـ (WEFE) الحيوية، وتبادل أفضل الممارسات بشأن الحلول المتكاملة، وإلى إبراز دور الذكاء الاصطناعي، وإنترنت الأشياء، ودمج الطاقة المتجددة، وتعزيز الشراكات العالمية، وتحسين طرق الإفادة من الثروات الوطنية لتحقيق التنمية المستدامة.

سيدي صاحب السمو الملكي، الحضور الكرام

قدّم الذكاء الاصطناعي أقوى الأدوات لاستخراج رؤى قابلة للتنفيذ من هذا الكمّ الهائل من البيانات المتاحة، ويمكّننا من الإفادة منه كنظام معلوماتي متكامل، كما ويمتلك القدرة على تحليلها وتحديد الأنماط، ويحسّن إدارة الموارد بطرقٍ لا يمكن للأساليب التقليدية أن تضاهيها.

فمثلاً، يمكن للذكاء الاصطناعي معالجة ندرة المياه في الأردن من خلال التنبؤ بالطلب عليها، واكتشاف التسريبات في الشبكات، وتحسين الاستخدام الرشيد، ويمكنه التنبؤ باحتياجات المياه المستقبلية من خلال تحليل عوامل مثل النموِ السكاني، بيانات المناخ، وأنماط الاستهلاك.

كما ويمكن للذكاء الاصطناعي تحسين كفاءة الشبكة الذكية من خلال تحسين إدارة العرض والطلب أثناء دمج الطاقة المتجدّدة، ويمكنه أن يُحدث ثورة في إنتاج الغذاء من خلال الزراعة الدقيقة، حيث يحلّل البيانات من أجهزة استشعارِ التربة، ويقدم قراءة دقيقة لخرائط الطقس، ويراقب صحة المحاصيل، وأنظمة الريّ والتسميد.

في الختام أجدّد شكري وتقديري لسموكم، وأشكر فرق العمل التي أعدت التقارير، والعلماء والخبراء المشاركين، وشركاءنا، الوكالة الألمانية للتعاون الدولي (GIZ) كما وأشكر الشبكة الإسلامية لتنمية وإدارة مصادر المياه INWRDAM، والزملاء أعضاء اللجنة التنظيمية للمؤتمر، وأخصُّ بالذكر الدكتور رائد عوده، والمهندسة رشا صمادي.

ودام الأردن عزيزاً منيعاً في ظلّ حضرة صاحب الجلالة الهاشمية الملك عبدالله الثاني ابن الحسين المعظم، والسلامُ عليكم ورحمةُ اللّه وبركاته.

سيدي صاحب السمو الملكي الأميرِ الحسن بن طلال المعظم، راعي المؤتمر. سعادة سفير جمهورية ألمانيا الاتحادية الدكتور بيرترام فون مولتكه. السادة الشركاء، الوكالة الألمانية للتعاون الدولي – (GIZ) أصحاب الدولة والمعالي والعطوفة. الحضور الكرام، السلام عليكم ورحمة اللّه وبركاته.

يُسعدني بأبهى مشاعر العرفان والامتنان الترحيب بكم سيدي، وأنتم تشرّفوننا برعايتكم الحانية المُلهمة لمؤتمرنا هذا، كما ويسعدني الترحيب بالباحثين والخبراء والحضور الكرام.

سيدي صاحب السمو الملكي، توجيهاتُكم الرشيدة كانت حافزنا الأكبر في المجلس الأعلى للعلوم والتكنولوجيا لتشكيل فرق عمل ضمّت خبراء من الجامعات والمراكز البحثية، والقطاعين العام والخاص، في مجالات المياه، والطاقة، والغذاء، والتغير المناخي الـ (WEFE)، وما بينها من تقاطعات، وكلٌّ فريق قدّم تقريراً خاصاً تناولَ وصفاً وتحليلاً لواقعِ الحال، والتحديات والحلول المقترحة، ونتوّجُ ذلك العمل كلّه اليوم بعقد هذا المؤتمر، سائلين المولى أن يوفقنا لنخرج بتوصيات ومقترحات تخدم بلدنا، وتسهمُ في رفعته وازدهاره.

كلمة سعادة السفير

الدكتور بيرترام فون مولتكه

سفير جمهورية المانيا الفدرالية في الأردن

Your Royal Highness Prince El Hassan Bin Talal,

Your Excellencies, Ladies & Gentlemen,

First let me thank you for inviting me this important conference here today and to give me the opportunity to speak to you.

When I arrived in Jordan a little more than one year ago, it did not take long for me to realize the severe challenges Jordan faces regarding the scarcity of water. I have since learned that while the world average availability of water is 500 cubic meters per capita, for Jordan we are talking about 60 cubic meters per capita. These numbers alone make it plain to understand for everyone with open eyes: in Jordan, water is a vital, yet scarce commodity. And when I think of my many visits around the country, I dare to say that in Jordan, water has always been a very scarce commodity.

Let me briefly mention in this context that in our bilateral cooperation between Germany and Jorden the water sector has been our major focus right from the beginning. Since 1980 Germany has made available a total of 6 billion euros for projects in this sector. And currently we are implementing water projects totalling some 1.5 billion Euros around the country. This goes to say that Germany, as many other partners have, has recognized the primordial importance of this issue, because is so important for the welfare and security of Jordan.

When I first read what this conference is all about, I must confess I had to consult my specialists. "AI" was something I could relate to immediately, but "WEFE Nexus" remained somewhat of an enigma to me at first. Having delved into the matter a bit deeper I have now understood that nexus between the water, energy, food and environment sectors. The idea behind this nexus turns out to be as simple as it is vital for the wellbeing of Jordan:

If we are thinking "water", we must at the same time think "energy", just as we have to think "food or agriculture" and "environment". Because these four sectors are closely linked to one another.

In order to help tackle the many complexities in dealing with four sectors at the same time, AI can certainly help. The way it can do this is the main topic of this conference. I sure hope that using this modern technology will indeed help to transform the way we understand the nexus. This in turn can help to develop strategies in order to satisfy in the best way possible the necessities in all four sectors.

If the nexus turns out to be a way of thinking and means working together across the boundaries of different sectors, people are needed who speak the same language, think alike, have a good understanding of the other sectors. I am aware that many highly qualified hard working and dedicated men and women think and work in the water, energy, food and environment sectors. But do they really speak the same language? Do they have an understanding of the issues in the other sectors, their limitations as well as their opportunities?

In case the answer turns out to be a clear "no" or a "probably not":
Would it not be great to have a cohort of young people educated from scratch with the nexus in mind? Would it not be an idea to create what I would call a "School of water management" on university level that offers students a comprehensive approach to water management, with the WEFE nexus incorporated?

To have students learn what their forefathers did to harvest and mange water. To give them a thorough understanding of the nexus to issues related to energy and food production. To make them understand the fundamentals of aquifers and geology and civil engineering, to give them a feeling of the needs and methods that exist in agriculture, to make them understand possible environmental implications of their interventions, to teach them the tools of how to administer a business, and to give them an idea of how water management is relevant in urban planning and architecture?

To my knowledge, at present no university curriculum offers this kind of wholistic approach in their programs. I am therefore very happy that the German Jordanian University has agreed to take up this idea by working out a possible new bachelor program offering this kind of education.

Ending my remarks, I hope that this conference and the implementation of the NEXUS will help Jordan to better manage its scarce resources across the four sectors, explore emerging technologies like AI and identify key research priorities.

Finally, let me extend my appreciation to the Higher Council for Science and Technology as well as GIZ for organizing this conference. I wish you all a productive and successful conference.

نبذة عن المؤتمر

تنفيذاً لتوجيهات صاحب السمو الملكي الأمير الحسن بن طلال المعظم رئيس المجلس الأعلى للعلوم والتكنولوجيا، عمل المجلس الأعلى للعلوم والتكنولوجيا على دراسة التكامل بين عناصر منظومة WEFE (المياه، والطاقة، والغذاء، والبيئة)، من خلال تشكيل فرق عمل متعددة تضم خبراء متخصصين في كل قطاع. حيث أعد كل فريق منهم تقريراً خاصاً بقطاعه تناول فيه وصفاً وتحليلاً لواقع الحال، والتحديات، وتوصيات مقترحة للعمل على تحقيق التكامل بين عناصر المنظومة.

توجت هذه الجهود بورقة سياسة مستقبلية حول ترابط قطاعات المياه والطاقة والغذاء والبيئة (WEFE NEXUS) لتحقيق التكامل عبر القطاعات لمواجهة التحديات المتعلقة بالموارد وضمان مستقبل مستدام للأجيال القادمة.

وجاء انعقاد هذا المؤتمر لتعميم ومشاركة هذا العمل المميز الذي انبثق عن هذا الجهد الوطني مع صنّاع القرار، وأصحاب العلاقة، والباحثين والخبراء من مختلف الجهات الحكومية والخاصة، والربط مع الجانب الصناعي لتقليل الفجوة بين المؤسسات التعليمية والصناعة وتعزيز الثقة المتبادلة بينهما. وكذلك لاستكشاف إمكانيات الذكاء الاصطناعي، وإنترنت الأشياء، والزراعة الدقيقة، وتكامل الطاقة المتجددة، وغيرها من التقنيات الناشئة في دعم قطاعات WEFE وتقاطعاتها.

وقد هدف المؤتمر إلى:

- عرض النتائج التي خَلُصَت إليها فرق العمل أمام أصحاب القرار في الأردن والخبراء للحصول على التغذية الراجعة منهم.
- التأكيد على ترابط قطاعات المياه، والطاقة، والغذاء، والبيئة (WEFE Nexus) من أجل التنمية المستدامة في الأردن ومعالجة التحديات الفريدة والمتعلقة بندرة الموارد.
- تعزيز التعاون بين قطاعات WEFE الحيوية في الأردن، وتبادل أفضل الممارسات بشأن الحلول المتكاملة.
- التركيز على دور الذكاء الاصطناعي والتقنيات الناشئة في دعم وتمتين قطاعات المياه والطاقة والغذاء والتغير المناخي وتقاطعاتها.
- دفع تطوير حلول مبتكرة وعملية قابلة للتطبيق على أرض الواقع في الأردن.
- إقرار التوصيات واقتراح الأولويات للبحث العلمي في قطاعات المياه والطاقة والغذاء والنظام البيئي، من خلال جلسة حوارية ختامية حضرها نخبة من صانعي القرار والخبراء المحليين والدوليين.

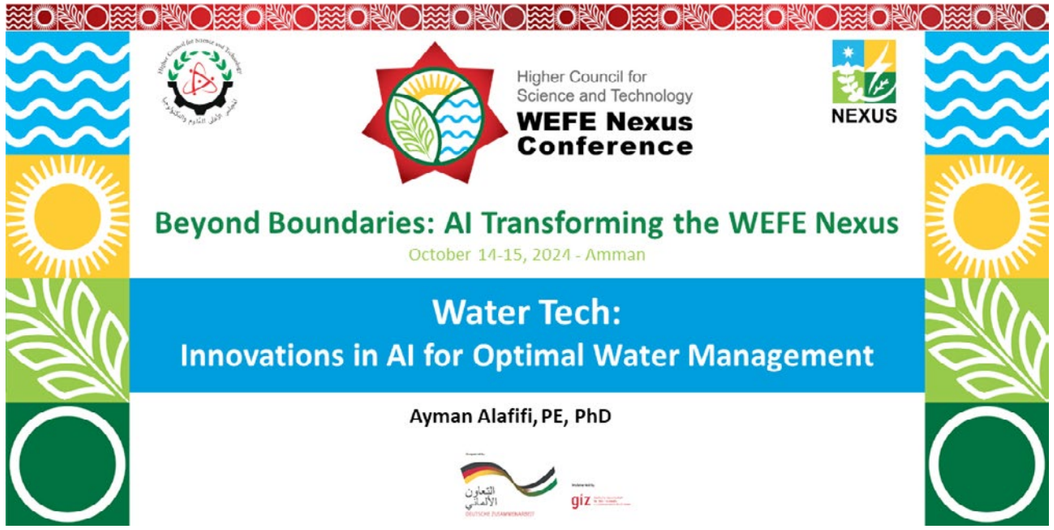
Session 1

WATER

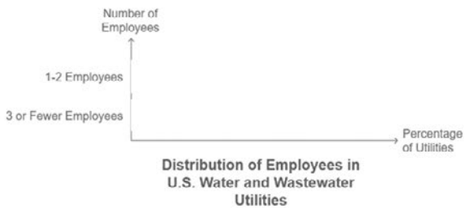
Water Keynote Speaker

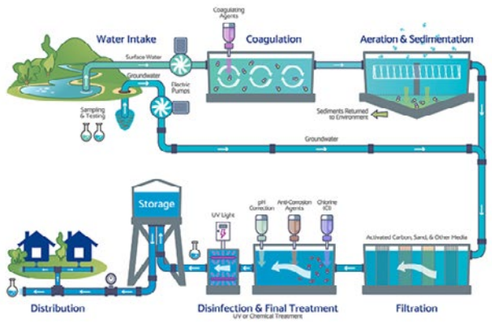
Dr. Ayman Alafifi

Technical Lead - Innovation at EKI Environment and Water, USA

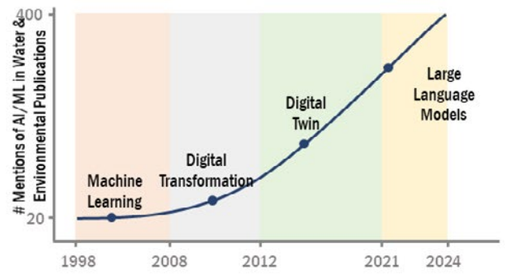


Introduction





Search for Efficiency



Data Driven Models:
- Identify patterns
- Make decisions
- Analyze/classify data
- Detect anomalies

Digital Twin
- Improve data analytics
- Predictive capability
- Risk-based planning

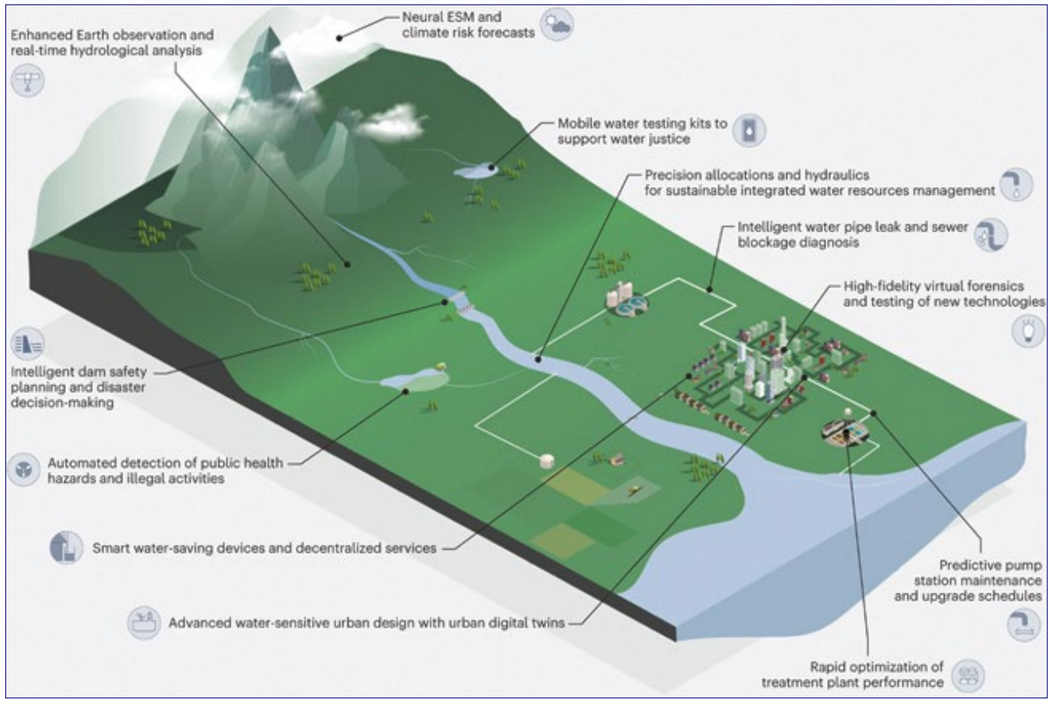
Digital Transformation
- Affordable sensors and better tools
- Improve data collection

Generative AI:
- Generate content
- Responsive interactions

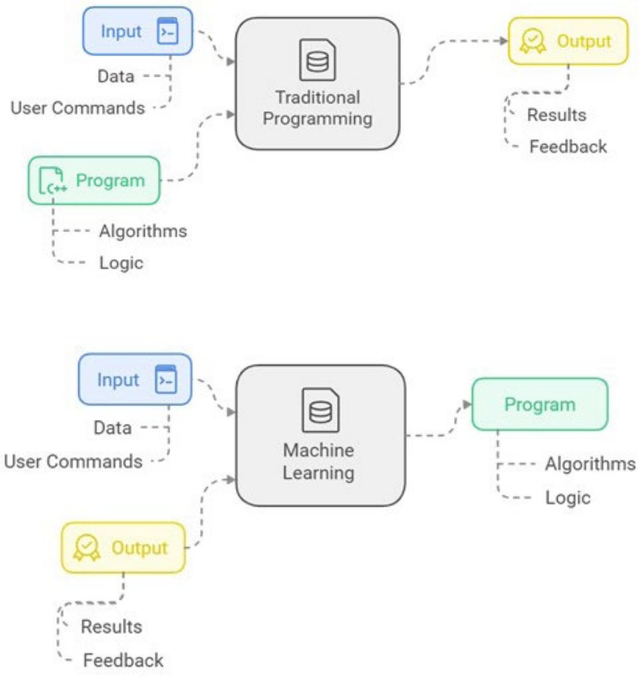
Leverage technology to do more with less

AI Applications

From watershed to end-users



What is Generative AI?



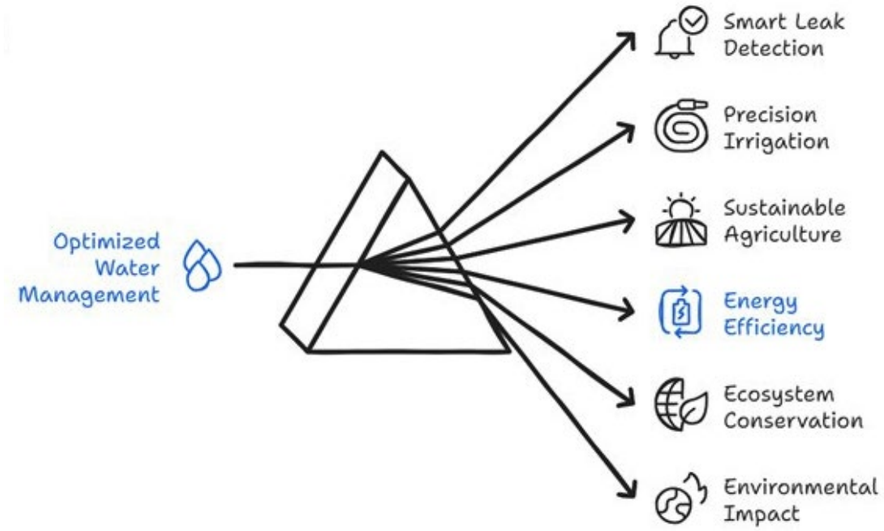
AI-powered Impacts on the Water Industry

Leverage technology to do more with less

- Optimal Management
- Collaboration
- Business Intelligence
- Automation

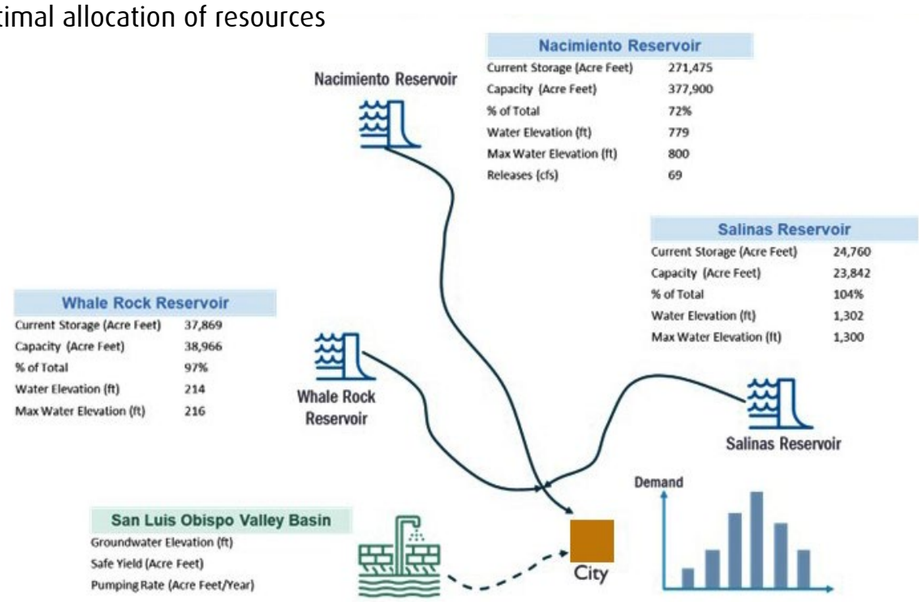
Optimal Management

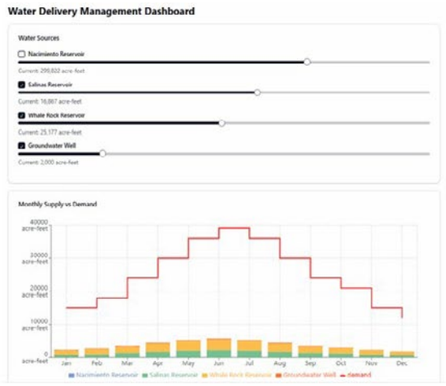
- Dynamic integrated resource management
- Cross-sector optimization and tradeoffs

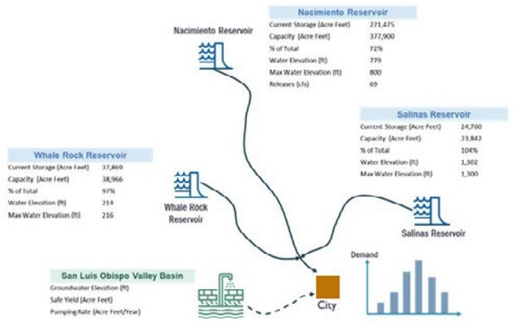


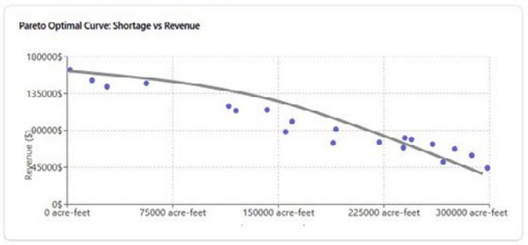
Optimal Management – Example

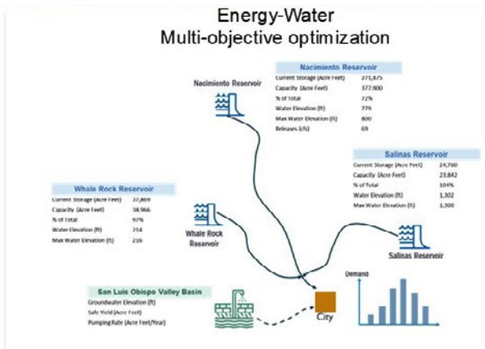
Optimal allocation of resources



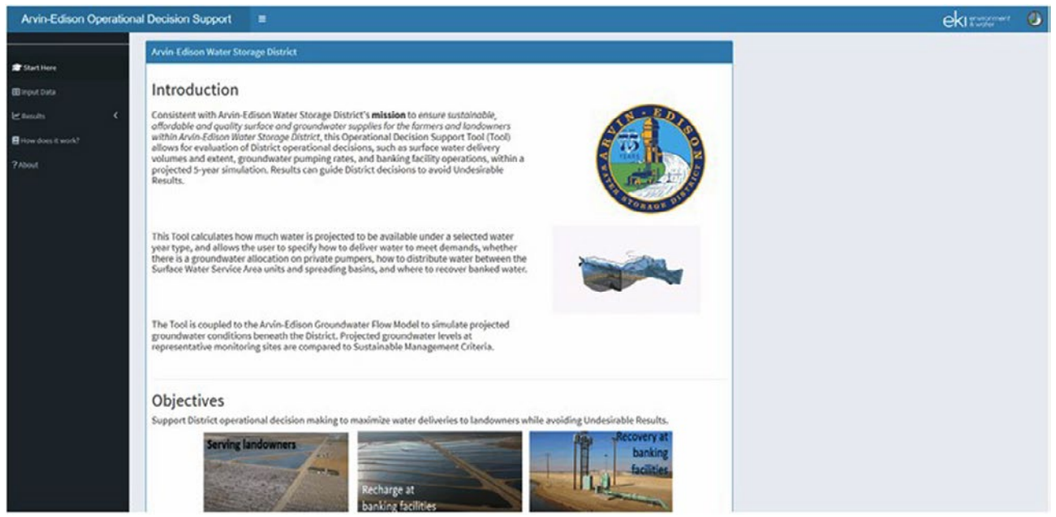




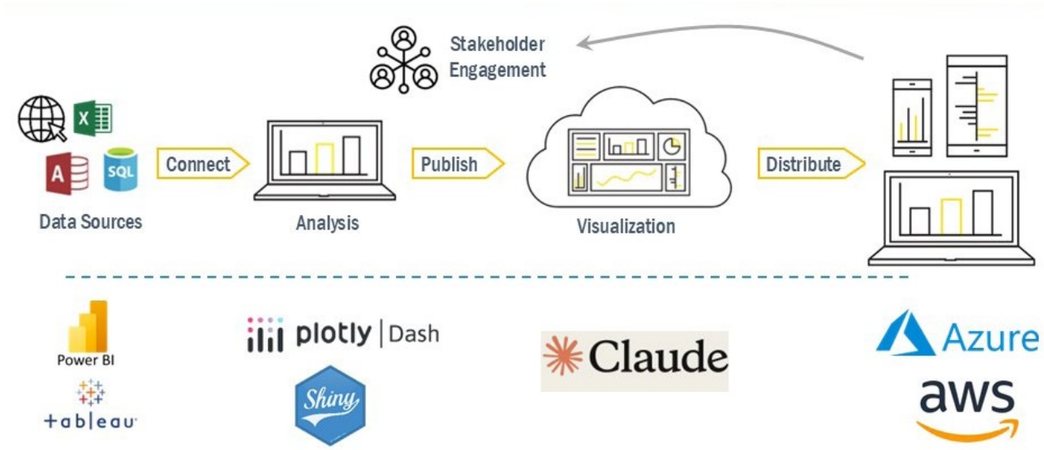




Groundwater Operational Decision Support Tool to calculate projected water availability

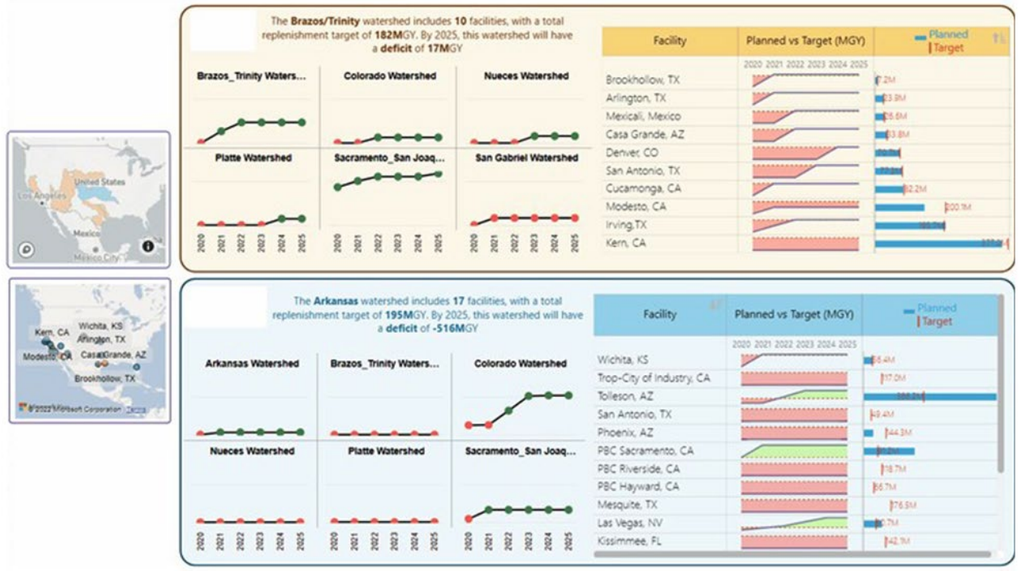


Business Intelligence

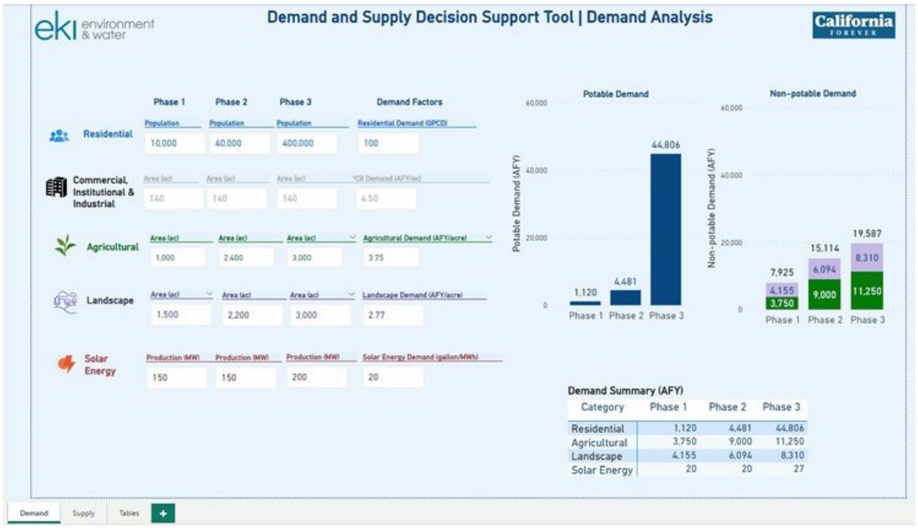


Business Intelligence – Example

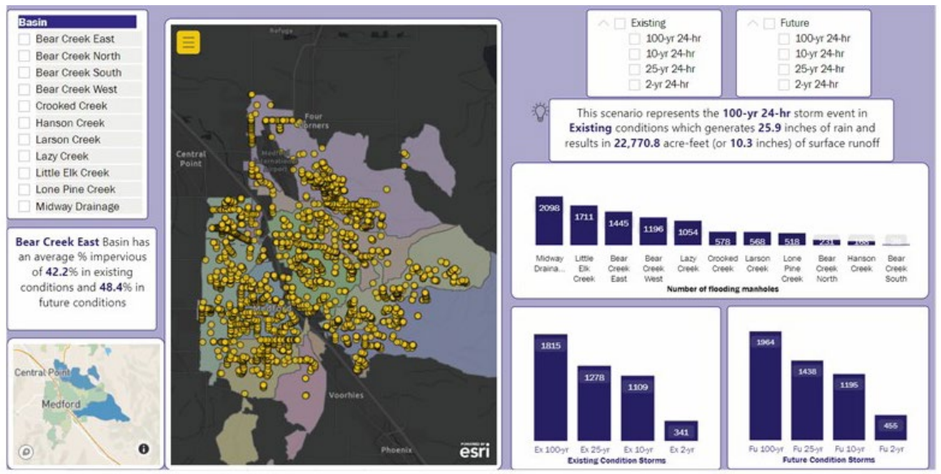
Water accounting dashboard supports performance evaluation and investment decisions



Demand and Supply Evaluation helps create portfolios of supply options to meet projected demand



Stormwater capital improvement projects

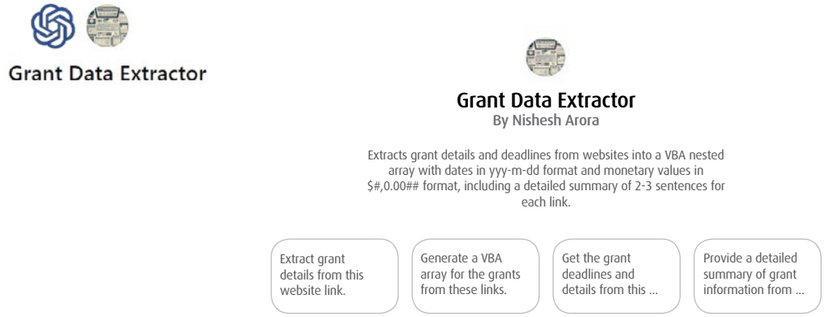


Automation

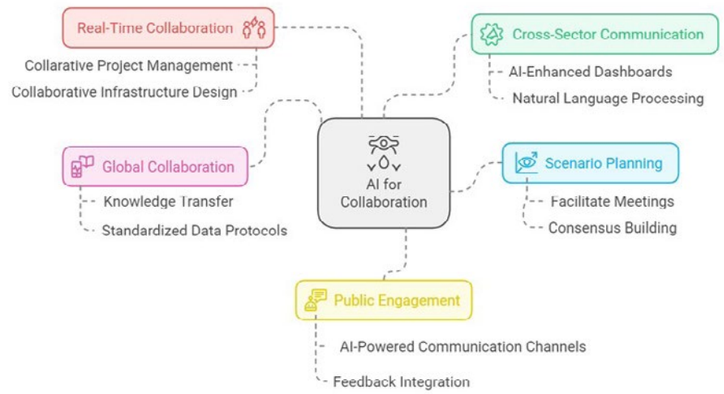
- Generate text (product description, creative writing, essays, etc.)
- Summarize text
- Improve writing, proofreading
- Write and possibly run code using different languages
- Produce digital art, graphic images, diagrams, videos, and slides
- Image to text detection
- Generate data for models

Sketch | Model | Render | Photo

Automation - Example

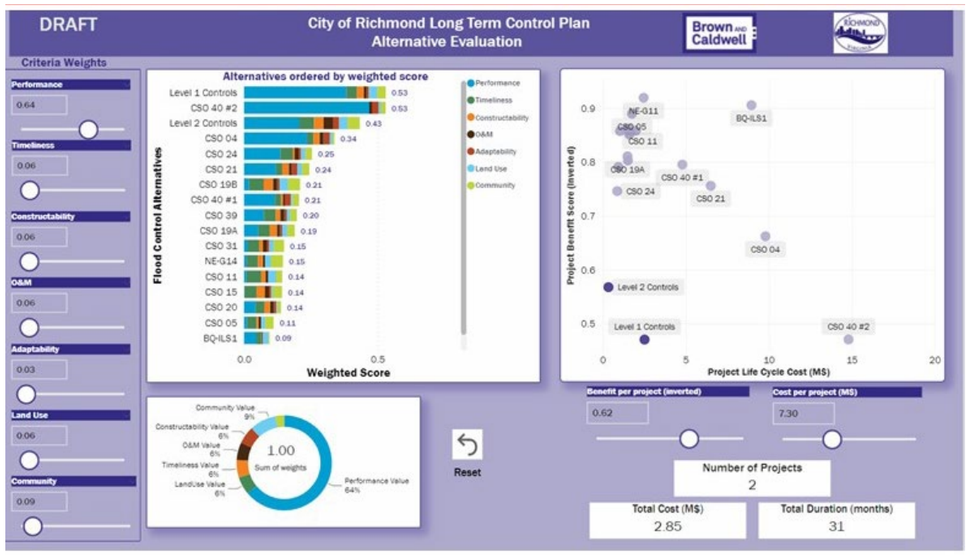


Collaboration

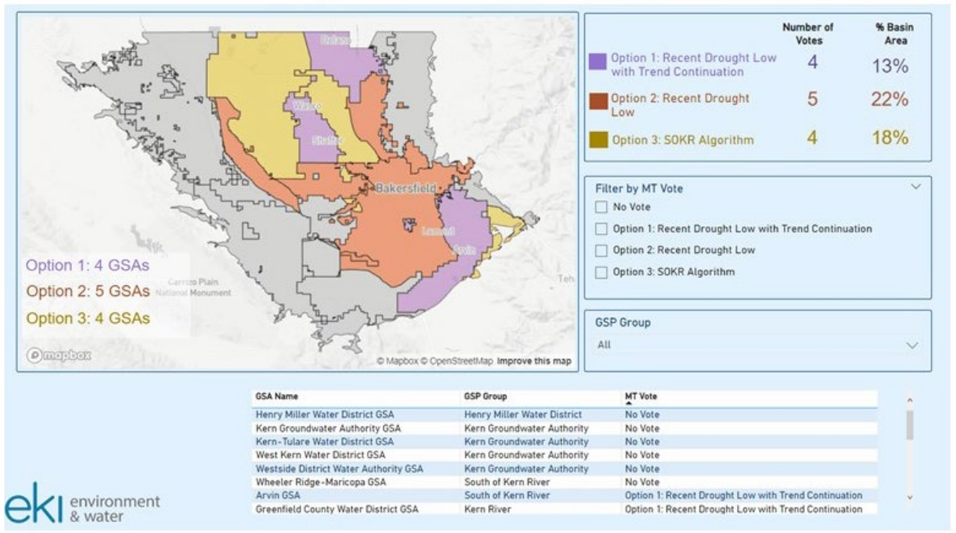


Collaboration – Example

Collective project prioritization



Workshop facilitation



Should We Use AI/LLMs?

Guidance for City staff using generative AI tools SF.GOV

DIVE BRIEF

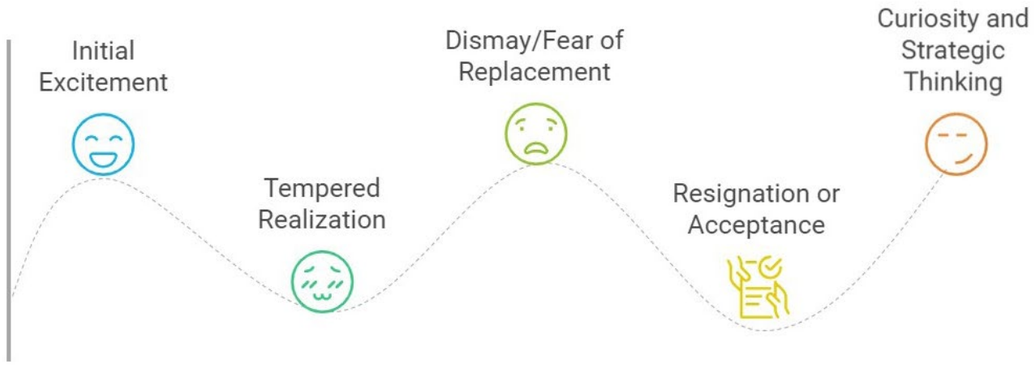
One in four companies ban GenAI

The research by Cisco found that generative artificial intelligence tools are putting many companies' sensitive data at increased risk of public exposure.

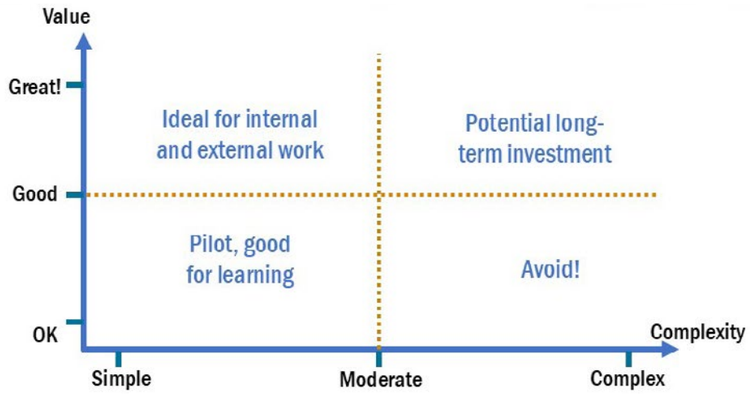
Prominent companies including JPMorgan Chase, Northrup Grumman, Apple, Verizon, and Spotify have entirely blocked internal use of ChatGPT, the wildly popular generative AI tool created by Microsoft-backed OpenAI, with several citing privacy and security concerns, CNN Business reported in September.

"We recognize both the potential benefits and risks these tools enable. We're neither frozen by the fears nor hypnotized by the upside."

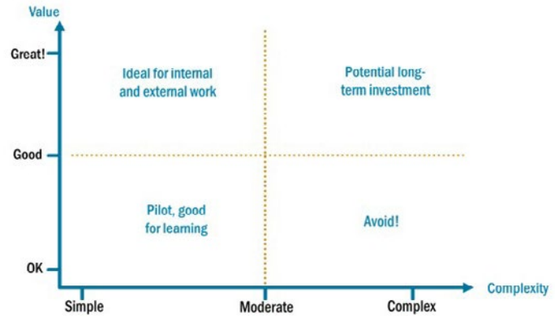
Emotional Journey of Adopting AI



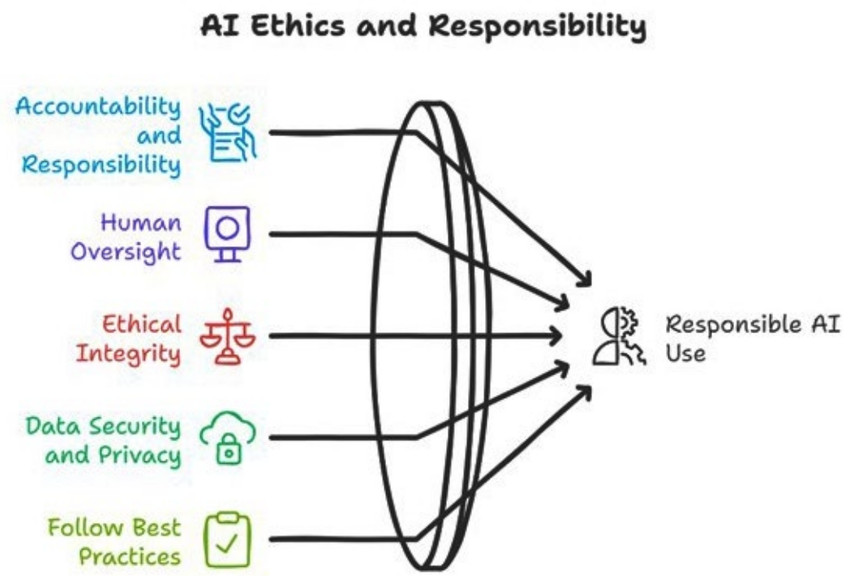
How do you Get Started?



- Data collection/query
- Data transformation and loading
- Automate data analysis
- Create user interfaces
- Proofreading, improve writing
- Brainstorming ideas
- Generate text/photos
- Summarize text
- Generate dummy data for model



Our Approach to Using AI



Takeaways and Looking Ahead

AI and Water Management: A Powerful Partnership

- AI won't replace us—it will **enhance** our work.
- From **resource optimization to collaboration**, we've seen real, impactful use cases.

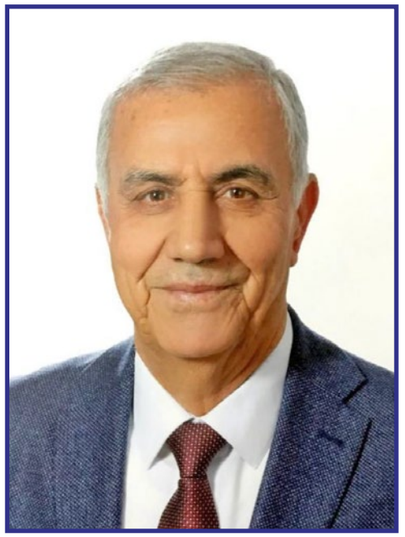
Start Small, Think Big

- Begin with pilot projects for learning and scaling.
- Focus on **high-value, low-complexity** applications.

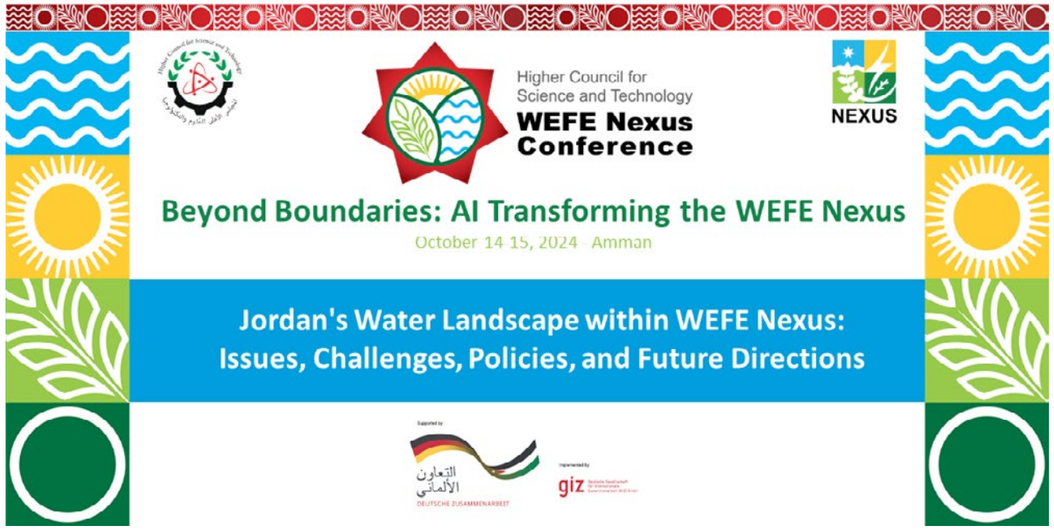
The Future: Bold, Innovative, Collaborative

- AI will revolutionize infrastructure design, risk management, and public engagement.
- The future of water management is in **our hands**—let's **embrace it together**.

HCST Water Sector Report Brief



Dr. Muhammad Shatanawi
Chair, Water Sectoral Committee



Water Sector Report

- Under the Guidance of HRH Prince El Hassan Bin Talal, the HCST mobilized a team of experts to address and develop solution to water issues in Jordan and its relation to WEFE nexus.
- The team consist of: Muhammad Shatanawi, Theib Oweis, Marwan Raqqad, Samer Talouzi, Majd Al Naber and Mufleh Al Alaween (August, 2023)
- The report was reviewed by the water sector committee: Muhammad Shatanawi, Radwan Al-Weshah, Majed Abu-Zreig and Almoayied Assayed (August, 2024).
- The report was used as key input in preparing the WEFE Nexus Report

Terms of Reference

1. Conduct an in-depth review of the existing state of the water sector.
2. Diagnose key issues, identify constraints to sustainable development, and highlight areas of particular concern.
3. Determine the technical, political, and governance needs required to enhance the sector's performance.
4. Identify the political, economic, social, and technical tools necessary for achieving desired changes, along with their methods of implementation.
5. Assign responsibilities to both public and private stakeholders, ensuring clear accountability.
6. Suggest initiatives, projects, and ideas aimed at driving significant improvements within the sector.
7. Promote collective action across the water-food-energy-climate change nexus, identifying opportunities for integrated solutions at all levels.

Introduction

- Jordan is situated in semi-arid to arid regions with an area of 89,400 km2
- Population of Jordan as of the middle of 2024 is 11.6 million people.
- Jordan faces significant water scarcity and stress so the per capita per year share of water is 95 cmpcy based on the total supply and 61 cmpcy based on renewable internal water resources.
- Volume of rainfall over Jordan is 8.18 BCM (92.7 mm) distributed as:
  a) 1 BCM as blue water (runoff and groundwater recharge),
  b) 1 BCM as green water to support rain-fed agriculture, forests, and pastures and
  c) the remaining (about 6.2 BCM or %75) are lost as evaporation.
- The erratic distribution of rain and climate change further worsen the situation. rainfall variation could be seen as: in 1966/67, rainfall reached 17.8 BCM while in 1988/89, it reached 3.0 BCM.

Water Resources in Jordan for 2022
Reference: Water Budget for Year 2022, (MWI, 2022)

Source	Amounts in MCM
Internal surface water	351.1
Shared Surface Water	137.8
Groundwater	418.0
Nonconventional Water	199.1
Total	1106.0

Internal Surface Water Resources for 2022 in MCM	
Base Flow of Wadis and Springs	218.2
Flood	132.9
Total	351.1

Shared Surface Water Resources for 2022 in MCM	
Water from Wahdah Dam and Yarmouk	30.5
Conveyance Pipe from Tiberius to KAC	107.3
Total	137.8

Groundwater resources and their uses in Jordan

- Renewable groundwater resources 275 MCM
- Non-renewable groundwater resources 143 MCM
- Pumping from renewable groundwater is 471 MCM
- Over-pumping from renewable groundwater is 196 MCM
- Pumping fron non-renewable groundwater is 186 MCM
- Total pumping from groundwater is 659 MCM suppling 381 MCM to domestic, 247 MCMto agriculture and 31 MCM to industry and other uses.

Reclaimed Wastewater

- There are thirty-two operational wastewater treatment plants (WWTPs) in Jordan designed to produce 244 MCM in 2022.
- The volume of treated wastewater has reached 196.2 MCM in 2022.
- About 177.5 MCM (%90) of reclaimed wastewater is used for irrigation About 140.5 MCM are used in the Jordan Valley and about 37 MCM in the Highland (37 MCM).
- As Samra WWTP produces 117 MCM of treaded effluent mixed with floodwater and other surface water sources are used for irrigation in the Jordan Valley.

Desalinated Water

- Brackish water desalination are limited to Abu Az Zeeghan spring to produce 3.6 MCM plus 1 MCM desalinated plant on Karamah Dam.
- Unknown quantities are being desalinated by farmers from relatively saline groundwater in the Jordan valley (estimated at 10 MCM). Few wells are treated by JVA. Both are counted as groundwater.
- One plant in Aqaba for desalination of sea water at a rate of 500 m3/hr by a fertilizer company.
- Aqaba-Amman Water Desalination and Conveyance Project (AAWDCP) is under final stages and it will provide about 300 MCM of desalinated water per year through the Jordan National Water Carrier Project.

The distribution of water supplies among sectors

Sector/ type	Surface water	Groundwater	Reclaimed wastewater	Desalinated water	Total	%
Domestic	136.6	381.3	0.0	2.9	520.8	46.0
Irrigation	150.0	246.7	175.0	0.0	571.7	50.4
Industrial	2.8	28.7	2.5	0.0	34.0	3.0
livestock	4.6	2.6	0.0	0.0	6.2	0.6
Total	294.0	659.3	177.5	2.9	1132.7	100

Quantities are in million cubic meters (MCM)
Reference: Water Budget for Year 2022, (MWI, 2022)

Domestic water use

- In 2022 ,521 MCM was supplied for domestic uses.
- About 457 MCM are distributed by three limited liability water companies (%88) and the rest by the Water Authority of Jordan.
- The main issues regarding water distributed are non-revenue water and the uneven distribution among users.
- Another major challenge facing the Water Authority and the distributing companies are the lack of adequate supply to some areas.
- Due the lack of design and inadequate pressure, many areas do not receive enough water supply.

Non-Revenue Water (NRW)

- Non-revenue water (NRW) or unaccounted-for water (UfW) is generally defined as the difference between the volume of water supplied in the water distribution system and the volume of water billed to the water consumers.
- The high level of NRW is an alarming figure and huge efforts should be made to reduce these losses. It has reached %47 level.
- It varies from area to area within the utility. NRW in Zarka has reach %56 while in Amman it was %40.6. Similarly, the variation in NRW between Irbid and Mafraq are %43 and %64, respectively.

Efforts to Reduce NRW

- The water companies with the supports given by USAID, GIZ and the world Bank are working to
- reduce the NRW to an acceptable level.
- The intention of Miyahuna in response to the 2016-2025 water strategy is to achieve sustainable
- reduction of water losses.
- Aqaba water company effort in reducing losses is achieved by installing ultrasonic flow meters
- and supplying continuous flow.
- Yarmouk effort has started by establishing a NRW unit and installing smart flow meres.
- The Economic Modernization Vision (2023) proposed some initiatives like reducing NRW by 2%
- annually and Improving water efficiency.

Issues and Challenges

- Besides other issues, the main problems facing Jordan in management of water are:
- Water Scarcity and Inefficient Water Management, where each contributes %50 to the problem.
- Water Scarcity: A growing global issue where the demand for freshwater exceeds the available supply. Causes are limited natural resources, population growth and refugees, and Climate Change
- Inefficient Water Management: Poor usage, distribution, and conservation practices exacerbating the scarcity of water resources.

Other Challenges

- Shortage in well trained human resources in the different fields related to the water sector and difficulty in attracting qualified and professional people to the water sector.
- Lack of sense of ownership by public to water and its related infrastructure and the need to public awareness programs.
- The low efficiency of water distribution systems for domestic and agricultural sectors where the NRW for domestic is about %46 while overall irrigation efficiency can barely reach %50.
- Absence of well-defined water rights and water uses which need to ensure full enforcement of laws and by laws concerning water and water rights.
- Illegal practices by suppliers and consumers of water for domestic and irrigation.
- Fragmented research in water and lack of team work and the need for establishing sustainable research groups on specific topics.
- Lack of problems identification to be addressed through applied research. This could be the responsibility of MWI.
- Little understanding and consensus on bringing users into participatory in order to adopt measures to ensure the active participatory by stakeholders in the planning and operation of the water sector activities whenever possible.

Actions needed to improve water sector performance

- Identify and define the performance indicators of the sector as NRW, Consumer satisfaction, reliability of supply, maintenance response, ...
- Make diagnostic studies on system efficiency in both agriculture and domestic sectors to identify the cause, sources and faith of losses.
- Prepare new and comprehensive studies on sustainable yield of renewable groundwater using state of art groundwater modelling supported by GIS and RS technique.
- Determine the extent of deep groundwater aquifers regarding their depth, potential yield and water quality to be used as a future source for brackish water desalination.
- Different agencies have to work collectively to apply and reinforce water laws, by-laws and regulations for protecting and sustaining water resources especially groundwater.
- Concentrate on human resources development through different means like sending for higher degree in areas needed, provide them with in-job training and link promotion to performance
- Explore different and reliable options for finding new water resources.
- Encourage research and innovation that work on improving water and irrigation efficiencies and those on improving water desalination as well as improving the efficiency of energy used in the water production and distribution.
- Encourage efficient use of water for agriculture by selecting the crops of added value and those of higher economic efficiency. This has to be associated with the use of high-tech and smart agriculture.
- Invest heavily on promoting public awareness programs for retinal water use and protecting water infrastructure.
- Take measures to cope with water scarcity in all sectors
- Make sure that augmenting water for future generation depend on additional water supplies through desalination and water saving through demand management.

Despite being one of the most water-scarce countries, Jordan has made significant strides in water management like:

- 93% of the population receives fresh water through the distribution network.
- More than 65% of households are connected to sewage networks, and 30% are served by safe sanitation methods.
- Over 90% of reclaimed water is reused for agricultural purposes. In 2022, the amount of reclaimed water reached about 180 million cubic meters.
- Locally grown fruits and vegetables are available in reasonable quantities and prices throughout the year, with a significant portion being exported to Arab and international markets.
- Due to advancements in health, environmental sanitation, water, and sewage services, the average life expectancy has increased from 46.5 years in 1955 to 75 years in 2023.

Water Strategies and Policies

- Water policy formulation started in 1995 by producing a set of policies with associated strategies as action plan
- In 1998, the Minister of W&I has taken the approval of the Cabinet of Ministers on a new water strategy for Jordan.
- In 2008, a new Jordan Water Strategy 2008-2022: Water for Life (MWI, 2009) was prepared by the Royal Committee.
- Jordan›s National Water Strategy (2016-2025) was lunched in 2016 to align with post-Millennium Development Goals era and the UN Sustainable Development Goals
- Recently (in 2023), the Ministry of Water and Irrigation adopted a national water strategy (2023- 2040) with a number of policies and capital investment programs.

The Economic Modernization Vision of 2023

The water strategic potential and priorities for Jordan as listed by the vision are:

- Achieve water security for Jordan in a financially sustainable manner to improve the overall quality of life.
- Create innovative channels for enhanced water production.
- Enable sustainable water use through demand management.
- Reduce inefficiencies throughout the system and prioritize municipal water use.
- Overall solve for the water scarcity issue by finding new sources, reducing water losses, attracting investments and enabling thoughtful and optimal use of water.

Proposed initiatives by the Economic Modernization Vision

- Reduce NRW by 2% annually.
- Launch national desalination projects.
- Provide opportunities for private sector investments.
- Improve the efficiency of energy use in the water sector, increase the use of renewable energy sources, and implement water dam-pumped energy storage projects.
- Improve water efficiency and financial self-sustainability.
- Upgrade water supply/demand management monitoring and control.
- Launch water conservation awareness program.
- Establish climate resilience and sustainable water use.
- Utilize technological solutions for water sustainability program
- Launch National Innovation Center.
- Proper implementation and enforcement of water laws and regulations.
- Establish Nexus Council (Water, Agriculture, Energy and Environment)

Water Scarcity Vs. Water Security

Water scarcity:
refers to the lack of sufficient available water resources to meet the demands of water within a region. It occurs when the demand for water exceeds the available supply. There are two types (i) **Physical scarcity** and (ii) **Economic Scarcity**. Water scarcity leads to reduced access to clean drinking water, agricultural and economic disruptions, environmental degradation, and conflicts over water resources.

Water security:
is the reliable availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, along with an acceptable level of waterrelated risks (like floods and droughts). The water security focuses on the availability of water, its quality, sustainability, equitable distribution, and management systems

Water Security in Jordan
This subject is for discussion
What level of water security do we have in Jordan?

Coping with water scarcity in Agriculture

- Maximizing the productivity of blue water resources.
- Restoring lost rainfall as green water.
- Recovering water in the Badia through water harvesting and storage.
- Adopting water-efficient farming practices like precision farming, which uses data and technology to monitor crops' water needs more closely and enable farmers to irrigate only when necessary.
- Setting policy and regulation that addresses water pricing and incentives and water rights and allocation
- Using efficient irrigation technologies like subsurface drip irrigation and smart irrigation Systems.
- Practicing crop selection and modification like: drought-resistant crops, crop shifting and selecting varieties with shorter growing cycles.
- Adopting soil-water management practices such as mulching, soil moisture retention, and conservation tillage.
- Reusing and recycling of water like: reclaimed wastewater and desalination for agriculture when economically feasible.
- Developing future agricultural policies and strategies that encourage stakeholders to use the above practices.

Paradigm Shift in Water Management

There is a need for a qualitative shift in water management including:

1. Investing in people and developing human resources.
2. Incorporate Artificial Inelegance (AI) into Water Management
3. Equitable distribution of water resources among regions, sectors, and populations.
4. Raising water awareness among the population.
5. Efficient distribution and use of water to reduce losses and improve productivity.
6. Improving water management in agriculture.
7. Augmenting new sources through brackish water desalination and then seawater desalination.

Water Research in Jordan

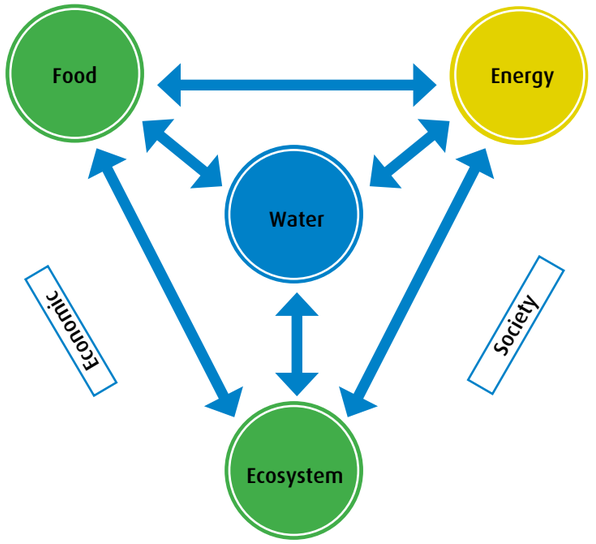
- Water research is primarily conducted by universities
- Support is provided by HCST and SRSF
- Research funds sometime are provided from the Universities Budget
- The main outside funder is the European Commission through different initiatives.
- The Ministry of Water and Irrigation and other related governmental bodies do not currently provide any research funds or support specifically dedicated to water research.
- Research in the water area are still fragmented and lacks comprehensive approach and team work.

Scientific Research Priorities in Water Sector

- Water Resource Management
- Climate Change Impact on Water Resources
- Water Governance and Policy
- Water Quality and Pollution Control
- Water-Energy-Food Nexus
- Integrated Water Resources Planning
- Social and Economic Aspects of Water Management
- Water Education and Awareness

Water, Energy, Food and Ecosystem Nexus

WEFE nexus approach is needed taking into account the complex interlinkages between these four key sectors: water, energy, agriculture, and ecosystems.



Water for Food

The water footprint required to produce one kilogram of some foods

Type of food	Liters to produce one kg
Wheat	1,300
Rice	2,500
Sugar	1,500
Beef	15,000
Lamb meat	10,000
Chicken	5,000
Potatoes	250
Tomatoes	180
Oranges	850

Water use in Food Production

- Irrigated agriculture in Jordan is concentrated in the Jordan Valley and highlands with an area of 865,000 dunums (about1%). Out of which. 510,000 in the highland and 355,000 in Jordan Rift Valley.
- Irrigated agriculture consumes approximately 571.7 MCM of water annually or about 50.5% of the total water supply in 2022.
- The rain fed ecosystem covers approximately 3.4 million dunums, accounting for less than 4% of Jordan›s total area. This include: residential areas, rainfed agriculture of one million dunums, forests and range land.
- The green water resources that support rainfed agriculture amount to about one BCM, with 0.4 BCM used for evapotranspiration by rainfed agriculture and 0.6 BCM used by forests and pastures in the highlands.
- The Badia ecosystem, representing about 93% of Jordan›s area, is characterized by annual precipitation of less than 200 mm.
- The Badia ecosystem can only support livestock feed for 1 to 2 months each year, necessitating supplementary feed for the remainder of the year.
- Rainfall in the Badia amounts to about 5 BCM annually.
- In the potentially productive zone with annual rainfall between 100-200 mm, approximately 11 million dunums receive about 1.6 BCM of rainwater annually.
- The area with less than 100 mm of annual rainfall covers about 72 million dunums and receives around 3.4 BCM of rainwater.

Water and Energy

- About 89% of the energy needs are imported, mainly oil and natural gas.
- Generation companies produced 22,134 GHw in 2022. From which, 19,306 GWh were sold to consumers while rest of 13% was lost.
- The total installed power capacity has reached 5.796 GW by the end of 2022. while the peak summer load of 2022 reached 4.24 GW
- Renewable energy is 27.4% in 2022 and projected to be 31% of electrical generation by 2030 and 14% of the overall energy mix.
- Energy consumption in 2022 were: 46% by the transport sector, 20% by the household sector, 20% by the industrial sector and 14% by the agriculture and water treatment and pumping sector.

Interconnection between Water and Energy

- **Water for Energy Production:** Hydropower, Power plants (nuclear, coal, natural gas) require large quantities of water for cooling purposes. Also, biomass for biofuels like ethanol requires significant water for crop irrigation.
- **Energy for Water Supply:** Extracting, treating, and distributing water requires energy e.g. to left one CM of water for 30 meter you need 50 kWh
- **Desalination:** Desalination of sea water is energy-intensive. It requires 325- KWh per cubic meter of water, depending on the method and technology.
- **Energy Water Footprint:** Producing 1 MWh of electricity requires about 700 liters of water on the average
- **Geothermal Power:** This energy source uses water or steam from underground to produce electricity.

Water for Ecosystem

- Ecosystem health is closely linked to water quality. Pollution from agricultural runoff, industrial discharge, or urban activities can degrade water quality, harming aquatic life and ecosystems.
- Ecosystems play a crucial role in regulating the climate by sequestering carbon dioxide and influencing local weather patterns. Water availability and vegetation cover within ecosystems influence their capacity to mitigate climate change impacts.
- Ecosystems rely on water for various processes such as habitat provision, nutrient cycling, and regulating climate.
- Habitat Provision: Water availability directly affects the distribution and quality of habitats within ecosystems. Wetlands, rivers, lakes, and oceans are all examples of habitats that depend on water.
- Water is essential for supporting biodiversity within ecosystems. It provides the necessary conditions for various species of plants and animals to thrive.
- Ecosystems provide essential services to human societies, such as water purification, flood regulation, and carbon sequestration.

AI in Water Management - Opportunities for Jordan

- **How AI Can Help in handling water challenges facing Jordan?**
  - Data-driven decision-making: AI can analyze vast amounts of data (e.g., weather forecasts, soil moisture levels) for real-time water resource management.
  - Predictive Analytics: Forecasts future water demand and availability, helping policymakers plan for water conservation measures.
  - Optimization of Water Distribution: AI can dynamically allocate water resources, ensuring equitable distribution to agriculture, industries, and households.
- **Key Benefits for Jordan**
  - Efficient Resource Use: Minimizes waste through better planning and distribution.
  - Cost Savings: Reduces operational costs in water infrastructure and management.
  - Increased Resilience: Prepares Jordan for droughts and climate variability through predictive tools.

AI-Driven Solutions for Water Management in Jordan

1- Smart Irrigation Systems

- **AI-based Sensors:** Monitor soil moisture and crop needs, optimizing water usage in agriculture.
- **Water Scheduling:** Automates irrigation based on weather forecasts and plant needs, reducing water waste.

2- Leak Detection & Prevention

- **AI for Pipe Networks:** Detects anomalies and leaks in real-time, reducing water losses in urban areas.
- **Predictive Maintenance:** AI can predict failures in water infrastructure, allowing for timely repairs and minimizing disruptions.

3- Water Quality Monitoring

- **AI-Powered Sensors:** Monitor real-time water quality, detecting contamination and ensuring safe drinking water.
- **Data Analytics:** Analyzes patterns in water quality to prevent future issues

Suggested Ideas, Initiatives, Programs or Projects

- Incorporate Artificial Intelligence (AI) into Water Management.
- Use the Water-Energy-Food-Ecosystems (WEFE) Nexus as a holistic approach to achieve all the SDGs
- Diagnostic studies to evaluate and monitor different forms of irrigation efficiencies.
- Re-evaluate the potential of renewable groundwater in Jordan
- Irrigated agriculture transformation initiative
- Green water initiative
- Badia rehabilitation program
- Comprehensive approach to Groundwater Resources Management
- Conduct integrated studies on the evaluation of deep aquifers in Jordan in terms of quantity and quality.
- Conduct studies on evaluating non-revenue water and proposing measures and actions to reduce it.
- Create Intensive Public Awareness Program for Water Conservation and Protection
- Investing in Human Resources Development in Jordan for Organizational Growth and Success
- Establishment of a Transboundary Water Negotiation unit.
- Introducing new technology like: Smart metering, smart irrigation, smart demand management using AI, SCADA system in monitoring, GIS, and creating data base.

Water Panel Discussion

Challenges and Opportunities in Water Management Technologies

Moderator:
Dr. Radwan Al-Weshah, Faculty of Engineering, The University of Jordan

Panelists:

- **Dr. Khaldoun Shatanawi**
  Director of Water, Energy and Environment Center, The University of Jordan

- **Dr. Majed Abu Zreig**
  President of Irbid National University

- **Eng. Malik Al-Rawashdeh**
  General Manager of Aqaba Water Company

- **Eng. Maysoon Zoubi**
  Chair of the Managing Committee of the Blue Peace Middle East

- **Eng. Mohammed Ouran**
  CEO of Jordan Water Company “Meyahuna”

- **Eng. Ra’fat Assi**
  Vice President at Royal Scientific Society

Session 2

ENERGY

Energy Keynote Speaker

Dr. Issa Batarseh

Department of Electrical and Computer Engineering,
University of Central Florida, USA

Higher Council for Science and Technology

WEFE Nexus Conference

NEXUS

Beyond Boundaries: AI Transforming the WEFE Nexus

October 14-15, 2024 - Amman

AI in Energy: Its Critical Role in Innovating and Transforming the Energy Sector

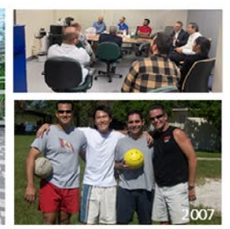
Issa Batarseh
University of Central Florida
Orlando, Florida, USA

Outline

- Background – *The UCF's Florida Power Electronics Center*
- Energy Transition: *Opportunity for Innovation and Entrepreneurship*
- Introduction to AI - Applications
- Nexus Connections
- AI Application to Smart Grids
- International Prospectives
- Concluding Remarks

Florida Power Electronics Center (FPEC)

Acknowledging or Research Team Members



Ph. D. graduated since 2018:

- Sumana Ghosh
- Mohamed Elrais
- Khalil Alluhaybi
- Fahad Al-aql
- Abdullah Al Hatlani
- S. khazeiynasab
- Xi Chan
- A. Bhattacharjee
- Md Safayatullah
- Reza Rezaii
- Sahin Gullu

Ph. D. Students (current):

- Anirudh Pise
- Russ Case
- M. Nilian
- Sandy Mignel

Post-docs/Affiliates:

- M. Rezaii
- N. Kutkutt
- H. Hu
- R. Rezaii

BS/MS Students:

- Yousef Abudyak
- Alexander Parady
- Jonah Spradnel

Florida Power Electronics Center (FPEC)

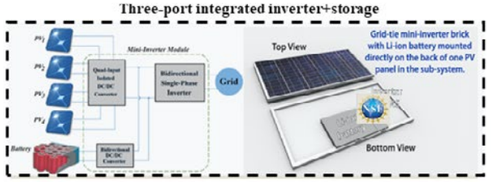
Research Focus: PV System control, modeling, design and architecture with Storage Integration

- The first to develop and commercialize *micro-inverter* from academia.
- Developed *3-phase microinverter*
- Designed and prototyped *three-port converter* with soft switching and high efficiency intended for space applications.
- Developed the highest power density *1/16 brick DC-DC* converters for Emerson.
- Two successful spin off companies: *Petra Systems and APECOR.*
- *Multi-port hybrid inverters*

First 3-phase micro-inverters

Multi Port DC DC system

Three-port integrated inverter+storage



Highest power density DC-DC

Commercialized micro-inverters

Multi-port PV GaN system

Florida Power Electronics Center (FPEC)

Commercialization & companies launched over the last 20 years:

ApECOR

ApECOR stands for Advanced Power Electronics Corporation. We are a small business organization that performs research and development and offers innovative products in the area of power electronics.

Multi-Port DC-DC system

DoD Solar Chargers

Petra Systems

Petra Systems is transforming energy-efficient streetlights into revenue-generating, renewable assets that deliver a smarter city through mobile voice and mobile data offload.

micro-inverters & smart communication

protium power systems

In 2022, Protium Power Systems, Inc (PPS) signed a license agreement to commercialize his first-ever grid-tied hybrid microinverter, seamlessly integrated with battery storage—all mounted at the back of the PV module. This development has generated considerable interest, and PPS has successfully raised its initial startup funds. The fully integrated modular system anticipated to reshape the landscape of affordable, scalable grid-tied hybrid microinverters and energy access solutions.

Three-port integrated inverter+storage

Multi-port PV GaN system

https://fpec.ucf.edu/spin-off-companies/

Energy Transition: *Opportunity for Innovation and Entrepreneurship*

- Photovoltaic (PV)
- Electric Storage (Batteries)
- Electric Vehicles (EV)
- Internet of Things (IoT)
- Artificial Intelligence (AI)
- Digital Twin (DT)

The Electric Grid

- Electrification .. *Engine for global economic growth and human progress*
- US Grid has 130 years of success with $2-3T investment
- Reliable, dispatchable, affordable, expandable, stable.
- Since ancient times, humanity has sought ***efficient energy systems*** to meet growing demands by exploiting available resources effectively

Grid transformation

- Major grid infrastructure is aging
- Accelerating retirements of coal fired power plants
- Increasing NG generation
- Accelerating deployment of renewables
- Storage capacity additions are on the rise.
- EV growth continues – increasing demand for electrification.
- Engaging AI
- Cyber Security challenges

Exponential technology is being added to the edge of the grid

The largest Man-made Machine on Earth

"The flow of energy should be the primary concern of economics"

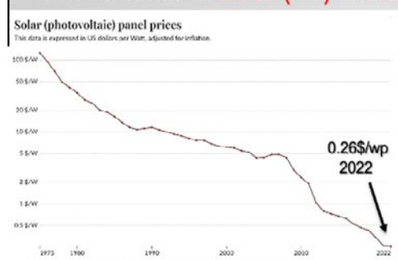
is in the making as the drive for reduced CO2 emissions continues:

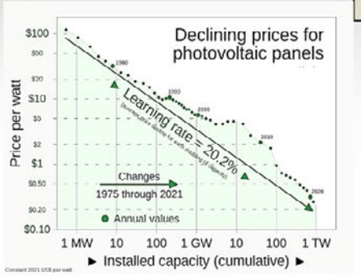
Energy Transition … massive global disruption underway

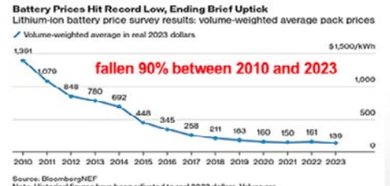
- Traditional energy is mainly from fossil fuels or nuclear – (thermal, dynamic pricing, Co2)
- Energy linked to a few powerful nations or corporations – (geopolitics of gas/oil)
- The global economy is intricately linked to the **efficient** generation, dist… management of electrical power.
- Developing countries have no control on energy market
- Still, developing countries are challenged to grow economies
- Top-down centralized & regulated structure:
  makes utilities risk averse , limit rate of innovation, unable to rapidly respond to change , and manage paradigm change

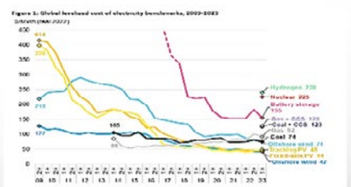
Energy transition will cause a major paradigm shift with unpredictable outcomes

Prices trends in Solar (PV) and Energy Storage (ES)









Driver: Steep & Sustained Learning Curves

Battery Cost
$/kWHr
2000 - $1500
2022 - $120
2023 - $94
2040 - $60

PV Cost
$/MWHr
2000 - $850
2022 - $22
2040 - $5

The cumulative production Doubled, the price went down by 25% for last 39 years

Ref: PHOTOVOLTAICS REPORT,2020 Fraunhofer Institute for Solar Energy Systems

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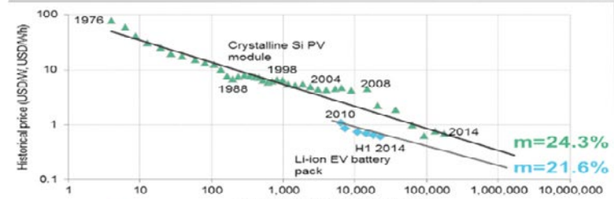
Prices trends in Solar (PV) and Energy Storage (ES)



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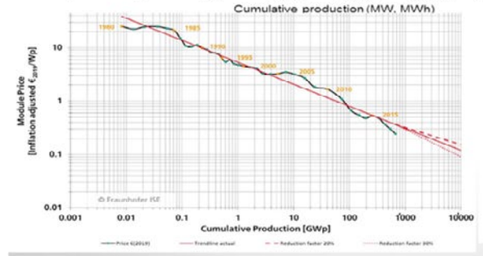

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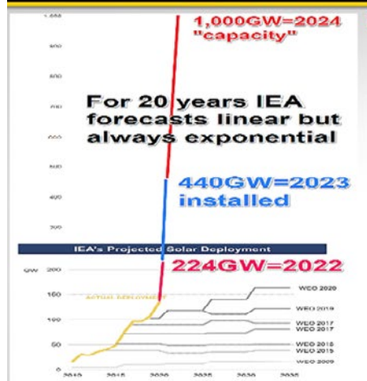
Energy Transition … massive global disruption underway



PV – IEA Projections vs Real Growth

All predictions for slow and planned growth have been disrupted by rapid growth of PV, wind, EV, & storage

In 2010 there was no utility, oil or automotive CEO who believed EVs, PV or storage would be cost competitive anytime soon! Every forecast made was spectacularly wrong! ***Terry Boston, Retd. CEO PJM***

Climate or Growth?

- Reducing CO2 emissions is not a goal – people want to improve lives, not generate CO2

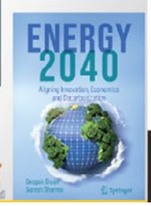
CAGR for Various Sectors (2040 est.)

PV/Solar	34% (500 GW pk)
Energy Storage	30% (125 GW pk)
Electric Vehicles	60% (1000 GW pk)
Transmission Grid	**0.25% (1000 mi/yr)**

Fast speed of commerce meets slow pace of regulation!

Source :https://www.pv-magazine.com/2023/06/08/global-pv-manufacturing-capacity-to-reach-1-tw-by-2024/

Courtesy



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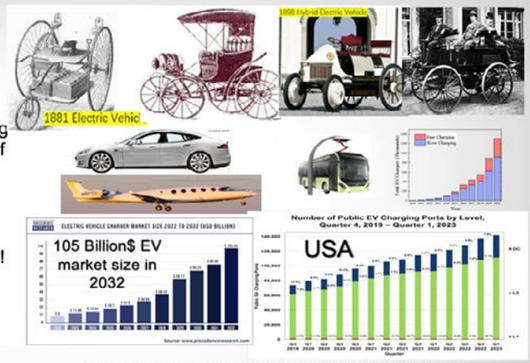
Opportunity: Increasing Demand for Electrification

- Major change in power electrification for transportation for all types of applications is approaching fast - *potentially will have significant effect -*
- Projections for annual production of EV reaching 20 Million by 2030. With the potential EV fleet of 130M (mostly passenger vehicles) on road.
- Electrification will drive demand growth, overloading distribution systems and causing transmission congestion. Total load may double!
- ICE vehicle production could fall from 97% in 2020 to as low as 10% in 2040.
- Needs major T&D upgrades if EVs are mainly charged from the grid
- Opportunities for innovation in batteries, power electronics processing and conversion systems, new power charging infrastructure



Source : https://www.precedenceresearch.com/electric-vehicle-charger-market

Source : https://www.energy.gov/eere/vehicles/articles/fotw-1300-july-24-2023-first-quarter-2023-215-all-public-electric-vehicle

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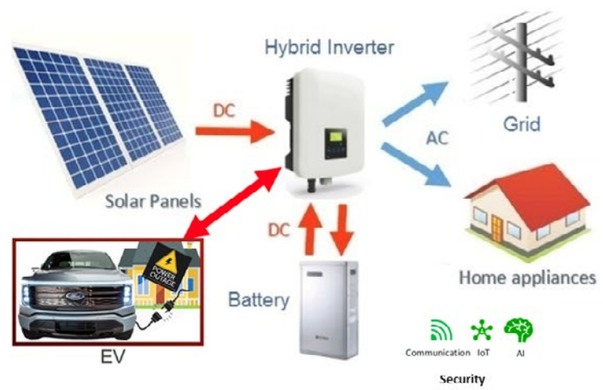
Where the PV market is heading?

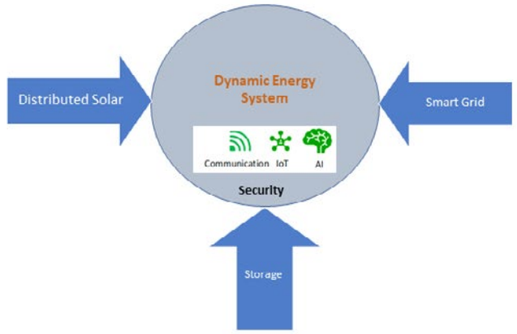
The Past (2010)	The Present (2020+)	The Future (2030+)
Deployment	Deployment	
Integration	Integration	
PV Module Prices		
$2-$3/W	$0.3/W	$0.20/W
Global PV Generation		
10+ TWh	300+ TWh	2000+ TWh
Global PV Installations		
10+ GW	300+ GW	1000+ GW

Building System-level Integration

- *PV module improvements in efficiency and cost alone will not accomplish the revenue model*
- *Complex installation and Expensive Value Chain*
- *Increased cost*
- *Reduced reliability and system efficiency*
- *Battery Operation at high ambient temperature*



The energy system integration



Integrating solar generation, storage, electronic and monitoring control, net metering, efficient delivery of energy, flexible, dynamic and self-correcting, communication,..etc

Industry Disruption - Electricity Market Dynamics

Centralized

- Large power plants
- Top-down power flow model
- Synchronous-machine dominated
- Emerging market player
- Consumers

Decentralized

- Increasing (distributed energy resources) DER & IBR
- Renewable generation is weather-dependent, leading to unpredictable power fluctuations that can overburden the grid.
- Transmission and Distribution System Operators must coordinate using geospatial data, especially for DERs
- A comprehensive solution is needed to model, monitor, forecast, and control power generation and dispatch.
- Prosumers

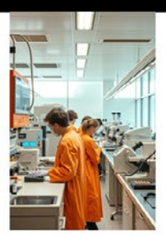
Energy Transition: Opportunity for Innovation and Entrepreneurship

- Today's Economic Growth is fueled by technological innovation
- Higher Education and Research Institutions play a primary role in driving innovation
- The Process known as ***Technology transfer*** is the key enablers for launch of new innovations
- *Innovation Ecosystems* is the Drive for Economic Impact

- **Expand high tech industry - Resources**
- **Engage the community - Outreach**
- **Facilitate tech transfer – Fund raising & commercialization**
- **Build Collaboration – Opportunity expansion**
- **Economic growth - Social impact**

Technology Transfer & Commercialization: An Ecosystem

The Bayh-Dole Act: A Catalyst for Innovation: How the Act has influenced global technology transfer frameworks:

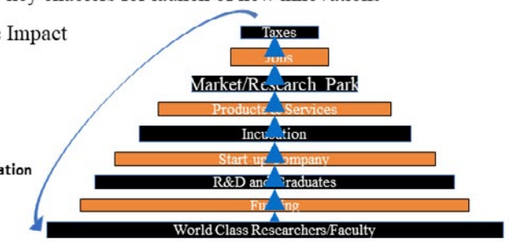


1. Technology Transfer: is moving innovations, knowledge, and intellectual property (IP) from research labs to the commercial marketplace
2. Commercialization: the phase of bringing IP to the market, transforming them into products or services: licensing, spin-offs, and scaling technologies
3. Technology Incubators: programs that support early-stage tech startups by providing resources, mentorship, and services at reduced costs and help to become self-sustaining businesses.
4. High-tech ecosystems: a network of stakeholders: research institutions, industry partners, government entities, and financial systems, that collaboratively drive innovation and commercialization of cutting-edge technologies.

Energy Transition: Opportunity for Innovation and Entrepreneurship

- Today's Economic Growth is fueled by technological innovation
- Higher Education and Research Institutions play a primary role in driving innovation
- The Process known as ***Technology transfer*** is the key enablers for launch of new innovations
- *Innovation Ecosystems* is the Drive for Economic Impact

- **Expand high tech industry - Resources**
- **Engage the community - Outreach**
- **Facilitate tech transfer – Fund raising & commercialization**
- **Build Collaboration – Opportunity expansion**
- **Economic growth - Social impact**



Lab to Market Economic Pyramid

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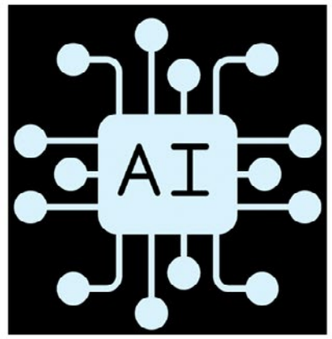
The age of AI → It has arrived!



- The **most significant** technological event of our times!
- There will be shuffling of **winners and losers** depending how each harness the power of AI.
- It is estimated that in the US alone, there will be saving up to $**1.6 trillion in productivity annually.**
- AI may result **in job losses**, particularly in roles that involve repetitive tasks, data processing, and certain types of manual labor.
- However, the overall impact, will deponent on how quickly workers and economies **adapt to the changes** brought about by AI.
- New opportunities are expected to emerge particularly in fields that require **creativity, critical thinking and emotional intelligence.**

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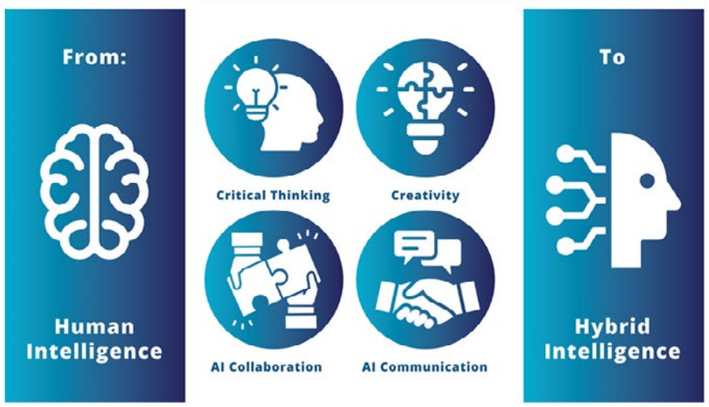
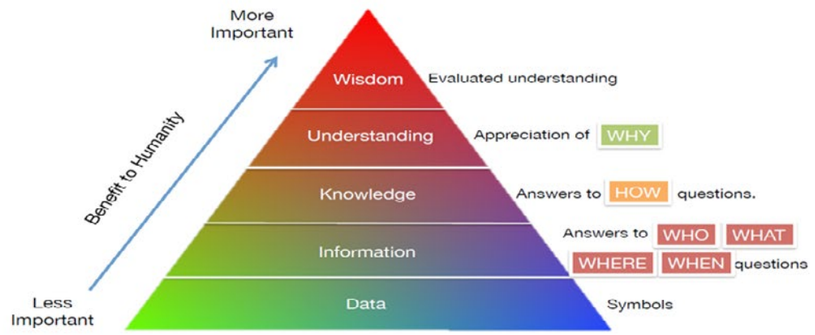
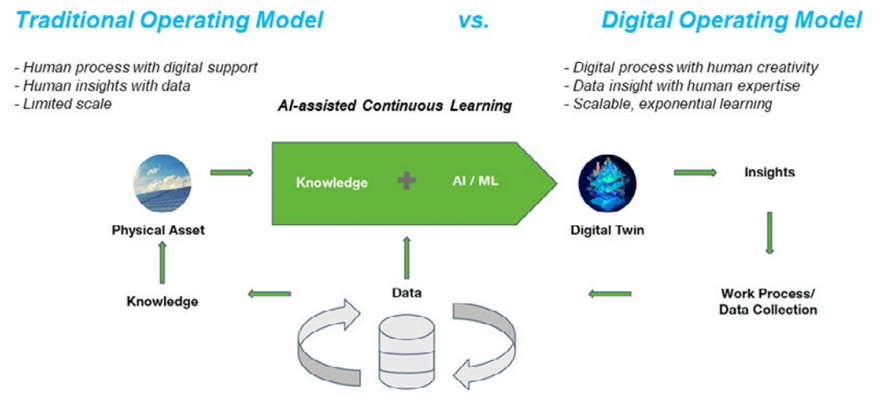
Human Intelligence → Hybrid Intelligence



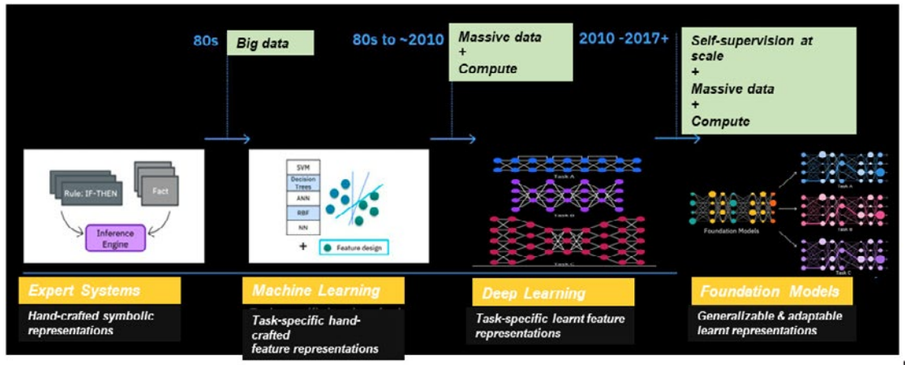
The age of AI → Turning Data into Wisdom (Value)



Digitalization - Industry Transformation



The Evolution of AI



IBM Research: The evolution of AI

AI in the WEF Nexus for Sustainable Development

WEF Nexus Overview:

The Water–Energy–Food nexus refers to the interconnectedness of water, energy, and food resources, where changes in one affect the others - crucial for achieving the **UN Sustainable Development Goals (SDGs).**

AI for Sustainability In WEF Nexus:

- AI can process vast amounts of data, offering insights into resource management, predicting the impacts of climate events.
- Optimize water, energy, and food systems, improving decision-making and sustainability efforts, and enhances system resilience to climate change.
- **Digital twins** and **predictive analytics** are used to simulate future scenarios, allowing for better planning and resource allocation.
- AI supports **multi-stakeholder** engagement by offering transparent, science-based solutions.

Business Model Transformation:

- AI enables sustainable business models by aligning WEF management with profitability and environmental goals.
- AI supports businesses in reducing costs while promoting responsible resource use.

AI Subdivisions

G. D'Amore, A. Di Vaio, D. Balsalobre-Lorente, and F. Boccia, "Artificial Intelligence in the Water–Energy–Food Model: A Holistic Approach towards Sustainable Development Goals," Sustainability, vol. 14, no. 2, p. 867, Jan. 2022, doi: https://doi.org/10.3390/su14020867

The Role of AI

Transportation:

AI can contribute to the development of efficient and eco-friendly transportation systems.
Autonomous vehicles can optimize routes and reduce fuel consumption.
AI-supported traffic management systems can reduce congestion and improve air quality.
AI's significant role in the design and operation of electric vehicles can contribute to a reduction in greenhouse gas emissions.

Waste Management:

AI can be used to manage and reduce waste effectively, by sorting waste more accurately and efficiently than humans and helping to increase recycling rates.
Predicts waste generation patterns and optimize waste collection routes, reducing fuel consumption and emissions.

Energy Consumption:

Optimizing energy consumption from multiple renewable sources and reducing waste.
Predict peak times, adjust energy distribution accordingly, and identify inefficiencies (A decade ago Google used AI to reduce the energy used for cooling its data centers by 40%)
Manage energy production and distribution, reducing losses and improving efficiency.

"AI-Driven Sustainability Solutions in a Changing World," Omdena. https://www.omdena.com/blog/ai-driven-sustainability-solutions-in-a-changing-world
"Moving Towards a More Sustainable Future Using AI | Capitol Technology University," www.captechu.edu. https://www.captechu.edu/blog/moving-towards-more-sustainable-future-using-ai

Nexus Connections - *Challenges*

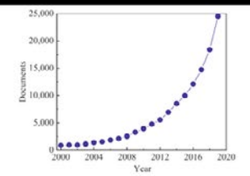
- AI require significant **financial and knowledge investment**, which may lead to digital inequalities.
- Potential for **e-waste generation and cybersecurity risks**, which must be managed for long-term sustainability.
- While each AI model delivers insight into a single part of the nexus, **incorporating the outputs of all the models illustrates several parts of the problem.**
- **Identifying appropriate technologies** represents an essential component of the nexus approach, to include structured processes of training, technical assistance in the management of technological solutions.
- Need to adopt **a multi-stakeholder approach** and the **important role** played by AI and other digital technologies.
- Current studies highlight the **scarce knowledge about the WEF nexus application to the UN 2030 Agenda** and its potential contributions.

WEF Nexus (from web)

G. D'Amore, A. Di Vaio, D. Balsalobre-Lorente, and F. Boccia, "Artificial Intelligence in the Water–Energy–Food Model: A Holistic Approach towards Sustainable Development Goals," Sustainability, vol. 14, no. 2, p. 867, Jan. 2022, doi: https://doi.org/10.3390/su14020867.

AI for Smart Grids

- Rapid rise of research investigations on how to apply AI to energy-related studies (almost 25% of AI research is related to energy).
- The techniques associated with AI include fuzzy logic, knowledge-based systems, and neural networks with IoT devices.
- They provide automated services to peers by *monitoring real-time information* to enhancing reliability, availability, resilience, stability, security, and sustainability.
- Smart Grid is an intelligent digital electric grid with a pool of technologies and services.
- DL, sub-branch of ML, employs large NN with many layers of processing units, advancing computing power, enhancing training techniques from vast amounts of data.



Number of publications in Scopus by searching "Energy+AI"

*Jin, Donghan, et al. **"Energy and AI." Energy and AI 1** (2020): 100002*

N. M. Kumar et al., "Distributed Energy Resources and the Application of AI, IoT, and Blockchain in Smart Grids," Energies, vol. 13, no. 21, p. 5739, Jan. 2020, doi: https://doi.org/10.3390/en13215739

UN Sustainable Development Goals

The Role of AI in Future Energy Systems

Shift to Decentralized Power Systems:

- Future energy systems will be more decentralized, requiring advanced real-time decision-making and control.
- Digitalization has spurred new business models in power generation and distribution.

Adoption of AI Technology:

- In response to fossil fuel depletion and unpredictable climate changes, more countries are adopting AI to address energy and environmental challenges.
- By 2030, AI is projected to contribute $15.7 trillion to the global economy, outpacing current output from China and India combined

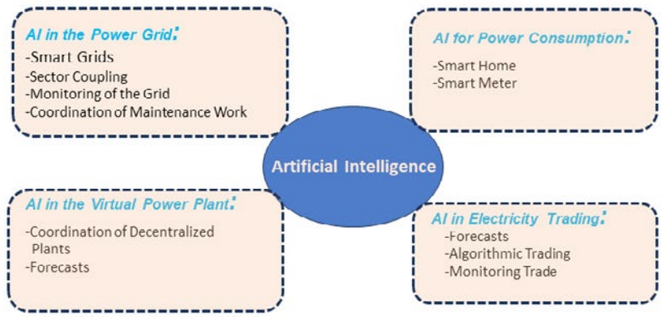
AI's Impact on Power Systems:

- AI-based techniques are being used to monitor, control, and optimize power delivery, reducing environmental impact.
- AI is helping solve key challenges in power systems like forecasting, scheduling, and planning, where traditional methods struggle.

AI is playing an increasingly pivotal role in transforming the energy sector and advancing sustainability goals.

Application of AI in Fields of Energy

The integration of AI and smart city technologies presents a vision of **smart energy ecosystems** that tackle energy sustainability issues through digitalization and machine learning.



Som, T. (2021). Sustainability in Energy Economy and Environment: Role of AI Based Techniques. In: Patnaik, S., Tajeddini, K., Jain, V. (eds) Computational Management. Modeling and Optimization in Science and Technologies, vol 18. Springer, Cham. https://doi.org/10.1007/978-3-030-72929-5_31

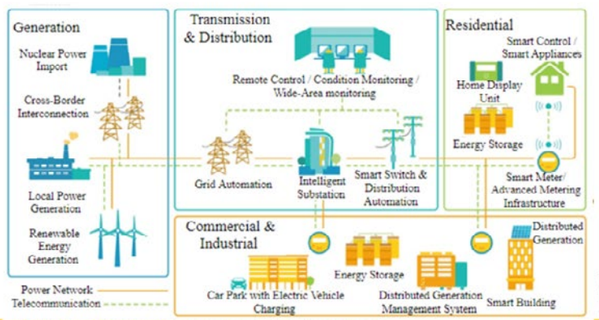
V. Rozite, J. Miller, and S. Oh, "Why AI and energy are the new power couple – Analysis," IEA, Nov. 02, 2023. https://www.iea.org/commentaries/why-ai-and-energy-are-the-new-power-couple

Conceptual Representation Smart Grids

Generation:
Monitoring, predicting, and controlling power generation processes, including managing micro-grids and controlling emissions.

Transmission & Distribution:
Grid automation, intelligent substations, smart switch and distribution automation, and managing and protecting equipment. And monitoring transmission lines and distribution automation.

Residential:
Focuses on smart appliances, energy storage, home display units, smart meters, and advanced metering infrastructure. IoT-based power control, energy management, and charging/discharging electric vehicles.



Commercial & Industrial: :

Covers similar technology but for commercial and industrial users, including energy management, intelligent vehicle charging, and distributed generation management systems.

N. M. Kumar et al., "Distributed Energy Resources and the Application of AI, IoT, and Blockchain in Smart Grids," Energies, vol. 13, no. 21, p. 5739, Jan. 2020, doi: https://doi.org/10.3390/en13215739

International Perspectives

- Energy firms see AI as an increasingly critical resource - ***AI and energy are the new power couple***
- AI already serves more than **50 different uses** in the energy system
- The market for the technology in the sector could be worth up to USD 13 billion
- **AI requires significant electricity**, complicating efforts to support energy transformation.
- **Data Security & Cyberattacks:**

Applications of AI

- AI systems in energy rely heavily on data quality and security.
- Digital connectivity exposes systems to cyberattacks, with a **300% increase in attacks on critical infrastructure**.
- Safeguarding the interconnected grid is crucial to protect against external threats and data breaches.
- Energy sector must continuously improve security measures to protect AI-driven systems

Case studies:

A) China - Wuqiangxi Hydropower Plant
B) MENA Region - Efficiency Between 2002–2021
C) Europe - Literature Survey from 2006 to 2023
D) USA – AI Initiatives in the Public and Private Sectors

V. Rozite, J. Miller, and S. Oh, "*Why AI and energy are the new power couple – Analysis*," *IEA*, Nov. 02, 2023. https://www.iea.org/commentaries/why-ai-and-energy-are-the-new-power-couple

What is Artificial Intelligence in the Energy Industry? https://www.next-kraftwerke.com/knowledge/artificial-intelligence, Accessed 3 Aug 2024

A) China - Wuqiangxi Hydropower Plant

- One of the world's top ten capacity hydropower companies in China introduced a set of **innovative tools** to help automatize and optimize **inspection and maintenance routines**.
- Every day at the Wuqiangxi hydropower plant (Hunan province) a fleet of robots and drones equipped with image and sound recognition tools, infrared thermometer and other devices, **patrol the machine floors to collect data.** This information is then used by a remote platform to give a diagnosis of the station's health in real time.

Wuqiangxi hydropower plant (from web)

- The Hydropower Smart Remote Operation and Maintenance (O&M) System has already helped the company save **10% on maintenance cost**, increase the time available for power production by 0.5% and **improve power generation by 0.3%.**

"Chinese operators are using AI to inspect their power plants," *www.hydropower.org*. https://www.hydropower.org/case-study/ai-power-plant

B) MENA Region - Efficiency Study Between 2002–2021

- Study attempts to estimate the **energy efficiency of the MENA** region between 2002–2021, heavy use and lowest energy costs
- Low use of AI in the region.
- The study showed that the interaction of AI standards and intelligent demand-response systems can improve energy efficiency scores.
- It reduces energy costs, decentralizing the grid, and enabling more sustainable energy systems and improve energy access to new technologies.

- AI is transforming the ways we use energy in the times of the internet of things (IoT), big data, and machining learning.
- AI integration to energy use in the form of load monitoring, small grid, demand side management, energy saving, revenue management, and smart meters are very vital to attain efficiency.
- The results confirm that countries such as Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Malta, Oman, Saudi Arabia, Tunisia, UAE and the West Bank are the most energy efficient

M. A. Hossin, D. Alemzero, R. Wang, M. M. Kamruzzaman, and M. N. Mhlanga, **"Examining artificial intelligence and energy efficiency in the MENA region** The dual approach of DEA and SFA," Energy Reports, vol. 9, pp. 4984–4994, Dec. 2023

C) Europe - Literature Survey - AI in the Energy Sector: Key Insights (2006-2023)

- **AI's Impact**: Deep learning and neural networks **enhance efficiency**, optimization, and short-term forecasting in clean energy systems.
- **Interdisciplinary Research**: Integrating AI with emerging clean energy technologies requires **collaboration across social, environmental, and policy fields**.
- **Machine Learning Benefits**: AI-driven energy management systems **reduce costs and improve efficiency.**
- **Innovative Applications**: AI aids in **discovering new materials** and advancing smart energy infrastructures and energy-sharing communities.
- **Focus Areas:** Recent research emphasizes AI's role in digitalization, **smart cities**, and optimizing green energy technologies.

Sabina Cristiana Necula, **"Assessing the Potential of Artificial Intelligence in Advancing Clean Energy Technologies in Europe: A Systematic Review,"** Energies, vol. 16, no. 22, pp. 7633–7633, Nov. 2023, doi: https://doi.org/10.3390/en16227633.

D) USA – AI in Energy Sector: Driving Innovation and Efficiency

US DoE and National Labs, aggressively supporting R&D of AI models for scientific and energy applications on the power grid.

Deep Learning Enhances Efficiency: AI, through NN, improves optimization and short-term forecasting in energy management.

Interdisciplinary Research: Integrating AI with clean energy innovations requires collaboration across sectors.

Cost and Efficiency: Machine learning reduces costs and enhances energy system efficiency.

Material Discovery: AI aids in discovering new materials for clean energy.
Revolutionizing Infrastructure: AI is transforming smart energy infrastructures and fostering energy-sharing communities.

Duke Energy set a goal to achieve net-zero methane emissions by 2030. It is difficult to make frequent checks of the natural gas pipelines that may leak, so the main existing method for finding methane leaks is to make calculated estimates.

Duke Energy explored new monitoring systems. The new platform started with measures of emissions from natural gas utilities, then added data from satellite monitoring and ground-level sensors.

AI assessed the data and provided reports in near real-time, so crews can be sent out quickly to repair the leaks, preventing an important source of greenhouse gas from entering the atmosphere.

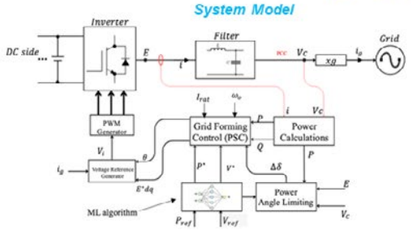
"AI for Energy." Energy.gov. https://www.energy.gov/cet/articles/ai-energy

N. Savage, "5 AI Case Studies in Energy," VKTR, Apr. 26, 2024. https://www.vktr.com/ai-disruption/5-ai-case-studies-in-energy/

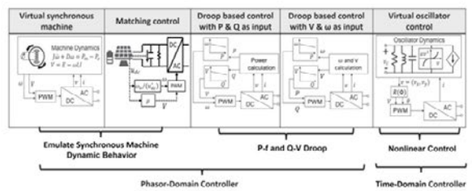
@UCF Grid Forming (GFM) Inverters Research

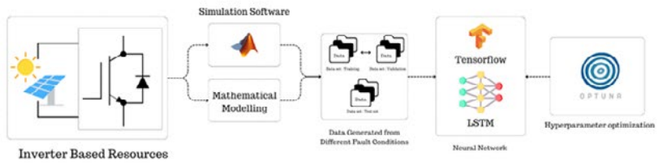
New control topology provided for Siemens Energy

System Model



Grid Forming Techniques





Digital Twin in RE integration
- *PV Fleet*
- *PV + Storage*
- *Power Electronics*
- *Smart Grid*

SIEMENS energy

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Grid Forming Inverters Research by FPEC Team

New control topology provided for Siemens Energy

The project comprises five core tasks:

1. Train and Develop Machine Learning Based Model: Develop and train a high-fidelity machine learning (ML) model of the system for the predictive fault detection and control optimization strategies.

2. Predictive Fault Detection: Employing advanced ML algorithms to identify and mitigate potential faults, enhancing system reliability

3. Enhanced Stability Control: A dedicated stability section optimizes system dynamics, ensuring robust operation under various grid conditions.

4. Enhanced PSC-based Control: A GFM controller, based on a power synchronization controller (PSC), enables seamless grid integration and robust voltage/frequency support.

5. Validation and Verification with Real Time Analysis: Conduct rigorous real-time testing and validation of the proposed controller architecture

SIEMENS energy

UCF

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Concluding Remarks

AI's Transformative Potential:

- AI plays a critical role in the energy transition.
- Impact across decentralized power systems, smart grids, and energy markets globally
- Optimizing resource use.
- Enhancing system efficiency.
- Facilitating the integration of renewables into the grid.

Sustainability:

- AI-driven solutions contribute significantly to sustainability goals by reducing environmental impact
- improving predictive maintenance
- Enabling real-time decision-making.
- Opportunity for innovation and entrepreneurship and economic growth in the energy sector.
- Opportunity for interdisciplinary collaboration

Challenges:

- Cybersecurity and safety
- Data quality,
- High investment cost and energy consumption
- Talent and skills acquisition

Opportunities:

- Advanced coordinated dynamics with fast and reliable communications.
- Solutions will be communication intensive, highly integrated and modular.
- Opportunity for interdisciplinary collaboration continuous innovation
- Harnessing AI's power in creating a sustainable energy future.

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EBL: A Global Challenge to Crowdsource Innovation

IEEE EMPOWER A BILLION LIVES is a recurring challenge to foster interdisciplinary innovation in the global community to develop and demonstrate solutions to energy access that are designed to scale, regionally relevant, holistic, and leverage 21st century technologies that feature exponentially declining prices.

- Innovation in **technologies**, social and environmental **impact**, and **business** models to rapidly and sustainably scale.
- The challenge is **open to all**, including small- and medium-sized companies, research labs, student teams, NGOs international corporations, and non-profit organizations.

It is not about access to energy – but how access to energy can transform lives and meet aspirations through improved livelihood, health, wellbeing & digital and financial inclusion.

575 teams have registered and 120 have competed in EBL I and EBL II

Ongoing competition cycles will drive a continuous learning process that allows successive generations of competitors to leverage past learnings, adopt fast-moving new emerging technologies, and demonstrate these capabilities and impact in realistic environments.

Empower A Billion Lives (EBL2025) Announced!

IEEE IDEAS Conference – Bali, Indonesia, Jan 8-11, 2025

www.empowerabillionlives.org

EBL 2023 Tracks

TRACK D: DECENTRALIZED UTILITY MODEL
TRACK C: CENTRALIZED UTILITY MODEL
TRACK A: AUTOMATION-CENTRIC SOLUTION
TRACK P: END-USE ENERGY (PRODUCTIVE USE)
TRACK E: ENABLING TECHNOLOGIES
TRACK S: STUDENT TEAMS

TECHNOLOGY
BUSINESS MODEL
SOCIAL IMPACT
FIELD TESTING

PRIZES & AWARDS
~$600,000
+STUDENT TEAMS

1 April 2022 — CONCEPT PAPER
1 August 2022 — FULL PROPOSAL
1 October 2022-15 January 2023 — FIELD TEST
GLOBAL FINAL — March 2023 Orlando, FL
Orlando, Florida, USA

Join the Movement!

- Solutions can range from an entire power generation, delivery, management system; appliances; enabling technologies.
- Teams can compete along the following tracks, noting that solutions may fit into more than one track:
  - TRACK T: TECHNOLOGY PROVIDER
    - ENERGY SUPPLY
    - END-USE (PRODUCTIVE USE)
    - CLEAN COOKING
    - ENABLING TECHNOLOGIES
  - TRACK E: LOCAL ENTREPRENEURSHIP
    - LAST MILE
    - LEAVE NO ONE BEHIND
  - TRACK S: STUDENT TEAMS
  - SPECIAL CATEGORY: CORPORATES

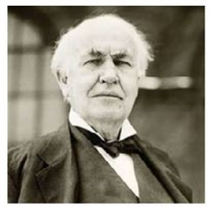
EBL 2025 Timeline

- Concept paper round: 1 July 2024 – 1 Nov 2024
  - Assessment by 1 Dec 2024
- Full Proposal round: 15 Dec 2024 – 28 Feb 2025,
  - Assessment by 31 March 2025
- Field Testing: 1 April 2025 – 30 June 2025
- Global Final: Sept 2025 at ECCE Europe

Key Events:

- ECCE Europe 2024, Sept 2-6 - launch, teams tutorial
- IDEAS conference, 7-9 Jan 2025, Bali, Indonesia – EBL matchmaking, EBL event
- Global Final: ECCE Europe, Sept 2025, EBL workshop

"I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait till oil and coal run out before we tackle that."



Thomas Edison, 1930's

Dr. Issa Batarseh
Issa.batarseh@ucf.edu
+1-407-962-8630
UNIVERSITY OF CENTRAL FLORIDA

HCST Energy Sector Report Brief

Dr. Majd Hawari
Member, Energy Sectoral Committee

Higher Council for Science and Technology

WEFE Nexus Conference

NEXUS

Beyond Boundaries: AI Transforming the WEFE Nexus

October 14-15, 2024 - Amman

HCST Energy Report Brief

Dr. Majd I. Hawwari, Ph.D.
Commissioner For Nuclear Research/Jordan Atomic Energy Commission (JAEC)

Energy Sector Report

Innovative Solutions to the Issues Associated with Water, Food, Energy, and Climate Change in Jordan

Outcomes & Recommendation

Energy Committee
(Eng. Walid Shahin, Dr Majd Hawwari, Dr Issa Alem, Eng. Zyad Sabra, Mr. Tarek Amad, Eng. Muhieddin Tawalbeh)

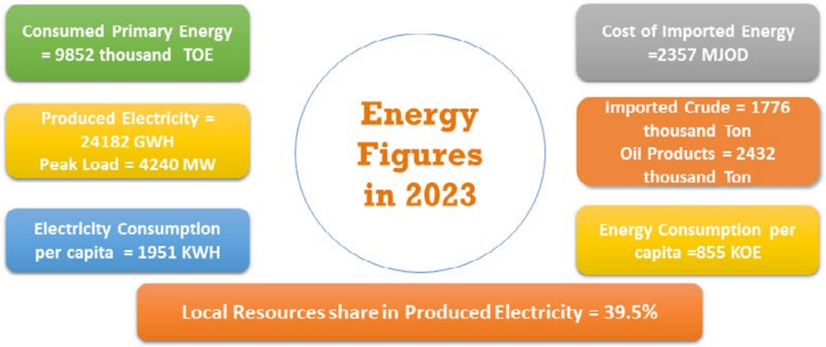
Introduction

- The Water-Energy-Food-Ecosystem (WEFE) Nexus refers to the interconnectedness of water, energy, food, and ecosystems, emphasizing that actions in one area often impact the others.
- Energy decisions directly influence water and food security.
- Renewable energy can produce the water used in agriculture, while clean energy sources can minimize environmental impacts and preserve ecosystems.
- This nexus approach is critical for sustainable development, as it ensures that resources are managed holistically, reducing conflicts, increasing efficiency.

Regulatory Framework of the Energy & Natural Resources Sector

- Natural Resources Sector Institutions
  - Institutions operating Mining Rights
  - Institutions operating in Quarries
- Electricity and Renewables Energy Sector Institutions
  - National Electric Power Co.
  - (8) Conventional Gen. Co.
  - (22) Solar Gen. Co.
  - (7) Wind Gen. Co.
  - Biogas Gen. Co.
  - (3) Electric Distributing Co.
  - Licensees to generate Electric Power for self/net metering and wheeling
- Radioactive and Nuclear Sector Institutions
  - Jordan Atomic Energy Commission
  - Jordan Research and Training Reactor
  - Synchrotron
  - Subcritical System (JSA)
  - Radioactive waste Treatment facility
  - Medical and Industrial Institutions
- Petroleum and Natural Gas Sector Institutions
  - National Petroleum Co.
  - Jordan Petroleum Refinery Co.
  - Jordan oil Terminal Co.
  - Jordanian Egyptian Fajr Co.
  - (3) Oil Products Marketing Co.
  - Fuel Stations, Central LPG Dis. Co., LPG cylinders depots, LPG cylinder Dis. agencies

Energy Figures in 2023



Renewables Contribution in Electricity Generation- 2023

Installed Capacity (Conventional) 4177 MW

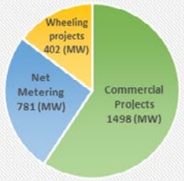
Installed Capacity (Renewable): 2681 MW

Renewables Contribution to Generated Electricity: 27%

Renewable Energy Capacities in Jordan 2023

The renewable energy share in electricity generation exceeded 27%

generation exceeded 27%



Commercial 56%

Net Metering 29%

Contracting Type	Capacity (MW_{AC})
Commercial	1498
Net Metering	781
Wheeling	402
Grand Total	2681

Jordan's Energy Sector Challenges

- **Energy Dependency:** Jordan is heavily reliant on imported energy resources.
- **High Energy Costs:** High energy costs burden both the government budget and consumer prices, negatively impacting economic growth and quality of life.
- **Limited Domestic Resources:** Jordan has limited domestic fossil fuel resources, necessitating the importation of most of its energy needs.
- **Energy Infrastructure:** Infrastructure development, maintenance, and expansion are crucial for Jordan›s energy sector.
- **Renewable Energy Integration:** Jordan has made significant strides in renewable energy, but integrating these sources into the national grid presents technical and financial challenges.
- **Water-Energy Nexus:** Balancing water and energy resources is a complex and pressing challenge due to Jordan›s critical water-energy nexus issue.
- **Environmental Impact:** Transitioning to renewable energy sources is essential for reducing greenhouse gas emissions and mitigating environmental impact. However, this shift requires substantial investment and careful planning to minimize ecological disruption.
- **Regulatory and Policy Framework:** Effective governance and a supportive regulatory environment are crucial for the development and growth of Jordan›s energy sector.
- **Economic and Political Instability:** Regional geopolitical tensions and economic instability can adversely affect energy imports, investments, and overall sector development.

National Objectives of the Energy Strategy (2020-2030)

Strategic Objectives of the Energy Strategy (2020-2030)

Energy Linkages with Water, Food and Ecosystem in Jordan

- **Water:** Jordan faces severe water shortages, low rainfall, high evaporation, and a 48% nonrevenuewater rate. Population growth and development strain resources, with the water sector using 15% of national electricity, expected to double by 2030.
- **Food:** Agriculture is vital to Jordan's economy, supplying key food products and contributing to exports. It supports 20% of the rural poor and consumes 5% of total energy, highlighting the need for sustainable energy practices.
- **Ecosystem:** Jordan must reduce GHG emissions to combat climate change. Investing in clean energy like hydrogen, nuclear, and geothermal, along with carbon taxes or cap-and-trade, can lower emissions. Carbon credits and efficient technologies can further cut emissions.

Recommendations Towards WEFE Nexus

- **Establish a Nexus Research Network:** Bridge the science-policy gap by creating a network involving academia, government, and the private sector to promote nexus technology implementation.
- **Create a National WEFE Nexus Council:** Establish a governing body to foster nexus governance best practices and bridge institutional gaps.
- **Adopt a WEFE Nexus Approach Policy:** Enhance policy coherence among the three sectors and climate change policies to provide integrated solutions and mitigate risks.
- **Implement Collaborative Capacity Building Programs:** Address the nexus capacity gap through training and development initiatives.
- **Support Integrated Resource Management:** Strengthen institutional structures for integrated resource management.
- **Apply Appropriate Policy and Economic Tools:** Ensure basic human needs are met while implementing pricing mechanisms to discourage excessive consumption.
- **Implement Integrated Planning and Management:** Reduce trade-offs and build synergies across the three sectors.

- **Promote Sustainable Consumption and Production:** Achieve SDGs and mitigate climate change impacts by promoting sustainable practices.
- **Scale Up and Replicate Successful Projects:** Expand and replicate existing nexus projects, such as integrated seawater energy and agricultural systems, renewable energy for wastewater treatment and reuse, and solar desalination.
- **Enhance the Role of Municipalities and Local Authorities:** Empower municipalities and local authorities to address WEFE nexus issues at the local level.
- **Build Capacity for Policy Makers:** Strengthen the capacity of policymakers and institutionalize regional knowledge management systems to share best practices on the WEFE nexus.
- **Encourage Energy Efficiency and Surplus Utilization:** Promote energy efficiency among consumers and explore ways to utilize surplus energy, such as providing it to the agricultural sector at low cost.
- **Promote Hydroponic Projects:** Encourage the adoption of hydroponic projects to conserve water and improve agricultural productivity.
- **Expand Regional Interconnections:** Strengthen energy connections with neighboring countries like Iraq, Saudi Arabia, Lebanon, and Egypt.
- **Utilize Energy Storage Systems:** Implement energy storage systems to improve grid stability and integrate renewable energy sources more effectively.
- **Use Renewable Energy for Water Pumping:** Employ renewable energy sources for water pumping, while carefully managing groundwater resources to avoid over-pumping.
- **Implement Carbon Credit Certification:** Establish a system for carbon credit certification to promote sustainable practices and offset emissions.
- **Implement Time-of-Use Tariffs:** Introduce time-of-use tariffs for net-metering and wheeling schemes to encourage energy efficiency and manage demand.
- **Promote Green Hydrogen/Ammonia:** Explore the potential of green hydrogen and ammonia as clean energy carriers and fuels.

Energy Panel Discussion

Challenges and Opportunities in Water Management Technologies

Moderator:
Eng. Wijdan AlRabadi, Advisor at the Energy and Minerals Regulatory Commission

Panelists:

- **Dr. Ahmad Al-Salaymeh**
  Department of Mechanical Engineering, The University of Jordan

- **Eng. Ahmad Duhni**
  Assistance Managing Director for planning and bulk supply, National Electric Power Company

- **Eng. Hanna Zaghloul**
  Chairman, Kawar Energy

- **Dr. Iyad AbuHaltam**
  Chairman, General Deluxe Company

- **Dr. Nadia Alrousan**
  Computer Engineering Department, The German Jordanian University

Session 3

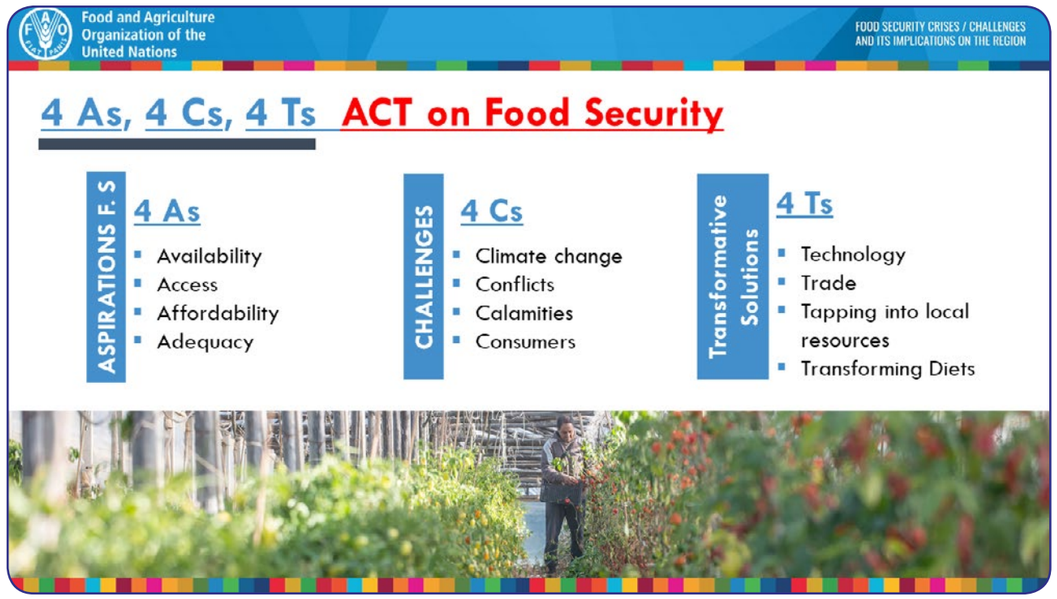
FOOD SECURITY

Food Security Keynote Speaker

Dr. AbdulHakim Elwaer

Regional Director, FAO

HCST Food Security Sector Report Brief



Note: The keynote speaker did not provide the full presentation.

Dr. Mahmud Duwayri

Chair, Food Security Sectoral Committee

Committee Members

The report was submitted by:	Present Committee Members:
- Mahmud Duwayri, - Rida Shibli, - Mustafa Qrunfleh, - Nizar Haddad, - Ayed Amr, - Hamed Takrouri, - Esam Yamani, - Abdel Rahman Sultan, - Mohammad Abu Jamous	- Mahmud Duwayri, - Nizar Haddad, - Hayel Obeidat - Theib Oweis - Husameddin HajAli

Scope of Work

The report document covers the following components within the Water, Energy, Food, and Environment Nexus in Jordan:

- **Agriculture,**
- **Food Industries,**
- **Nutrition, and**
- **Humanitarian action**

The strengths and weaknesses of the different components in the Food Security were highlighted.

Food Security

This group has in mind the Sustainable Development Goals (SDGs) by the United Nations, especially the SDG2: Zero Hunger, which states "End hunger, achieve food security and improved nutrition and promote sustainable agriculture".

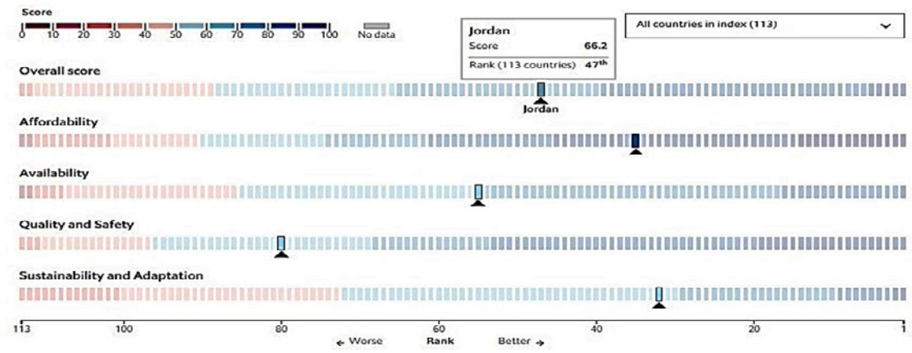
"Food Security" exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life.
The Food Security pillars are: Availability, Access, Utilization, Stability, Agency and Sustainability, defined as following:

1. Food Availability: Having sufficient quantities of appropriate food available.
2. Economic and Physical Access to Food: Having adequate income or other resources to access food.
3. Food Utilization/consumption: Having adequate dietary intake and the ability to absorb and use nutrients in the body. It is commonly understood as the way the body makes the most of various nutrients.
4. Food Stability : Refers to the constancy of the previous three dimensions.
5. Agency: The capacity of individuals and groups to exercise voice and make decisions about their food systems.
6. Food Sustainability: It refers to the long term variability of the ecological and social basis of food systems.

Food Security Status in Jordan

- Jordan is considered a food secure country with a score of 8.8 on the Global Hunger Index (GHI), 2020. GHI scores based on a 100-point scale, where 0 is the best score (no hunger) and 100 is the worst.
- Jordan published the "National food security strategy 2021-2030" and National plans for public sector and economic modernization.
- Given that Jordan's ranking in the Global Food Security Index (GFSI) is 47 out of 113 countries, the Government (through the Food Security Council) is working on improving Jordan's ranking in this index.

Food Security Status in Jordan-(GFSI), 2022



Food Security Status in Jordan

- Water stress and climate change: The agricultural sector uses more than 48.6% of the country's available water resources. Climate change could further reduce water supply and crop productivity, thereby potentially decreasing Jordan's GDP by as much as 6.8%.
- The agricultural area in Jordan is 400,000 hectares (ha) (4.5% of Jordan's land area).
- The agriculture sector is the main source of income for about 15% of the population.
- Agricultural products account for 25 % of the grand total of Jordan's exports.
- Most Jordanians spend 30–40% of their income on food. Relative to other food groups, the consumption of meat, dairy, eggs and sugar has increased over the past two decades.
- The food system contributes to national food security and represents 1520%- of the value chain of the GDP.
- Progress towards global nutrition targets: Although only 3% of all Jordanians are experiencing severe undernourishment, the rate of undernourishment amongst the country's large refugee population is 21%, and two thirds are at risk.
- Cereals, self-sufficiency is very low, while sufficiency in vegetables, poultry, is high.
- Changing consumption patterns and obesity: The national average intake of food groups associated with health and environmental impact (e.g. red meat, fish and dairy) by adults 20 years of age and older significantly exceeds the recommended daily intake. In 2019, more than 46% of women older than 18 years were obese, 37.7% of women of reproductive age (15–49 years) were affected by anemia, and 18.9% of all women (18 years or older) had diabetes.
- Food Processing: Most of Jordan's 4,000 food-processing businesses are concentrated around the major cities and involved in baking, dairy and the preparation and packaging of food. Foodprocessing revenues represent 4.13% of the national GDP. The food-processing industry is growing rapidly, with the demand for ingredients expected to double in the next five years.
- The prevalence of severe food insecurity among the total population has reached %17 for the period 2019-2021.
- Rising food prices: Since 2015, the consumer price index for food has increased by more than 5%, thus having an impact on the affordability of a healthy diet, particularly in terms of meat, poultry, legumes and fruit. Jordan is also highly dependent on global markets, as it imports around 70% of its staple food needs.
- The agriculture sector in Jordan employs 11.5% of the workforce, with a higher proportion of informal labor. Foreign labor is significant in the sector, with over 30,000 foreign workers employed in the agricultural sector in the country.

Recommendations for Agricultural Sector

- Enhancing policies and enforcing legislations related to the agricultural sector, which should provide further support to small-holder farmers, and other new regulations to provide accessible infrastructure that can help in developing all marketing strategy planning tools.
- Enhancing food supply and value chains through improved infrastructure, logistics, and market access to reduce post-harvest losses and strengthen the domestic food system.
- Encouraging use of advanced agricultural technologies (precision agriculture and climate smart agriculture), in addition of its role in increasing economic profitability of farmers and farm owners by increasing productivity and decreasing all aspects of losses on the farms, it also can help in maintaining the sustainability of funded projects.
- Developing innovative research and entrepreneurship, one of the proposed actions is to establish the Agricultural Research Hub (ARH) to act as an umbrella to all entities working on the agricultural sector. The hub can organize the research process to conduct more distinguished and problem-solving researches, conduct capacity building for researchers, and develop collaboration and partnership among other public sectors on one side, and between public and private sector on the other.
- Addressing post-harvest and agricultural input losses through improved storage, handling, and processing practices at the national level.
- Increasing crop productivity and water use efficiency in agriculture through the adoption of efficient irrigation systems, water management practices, and the promotion of water-saving techniques.
- Conserving biodiversity by working on rehabilitating rangelands that can also help in reducing the reliance on imported fodders. Afforestation is another important strategy to conserve biodiversity besides using new agricultural practices that conserve land and water such as multi - cropping and agroforestry. In addition, there is a need to establish projects for the sustainable use of biodiversity.
- The need of developing a comprehensive planning approach to maximize benefits of Al -Hamad and Al-Sarhan basins and support Nexus projects there that integrate water, food, and energy.
- Supporting the National Agricultural Research Center (NARC), the scientific arm of the Ministry of Agriculture, and the only center that conducts researches across Jordan in all field of agriculture, to act as a center for food and agricultural research, in which it can provide strategical research plans for all other agricultural research entities (universities and centers) about the priorities of research subject that is required to solve problems. The center can have a digital platform that include all researches output at national level as database required to build upon its results.
- The need to develop the scientific laboratories at NARC to be prepared as a national center for the universities to conduct their researches. Other actions are recommended to support food researches.

Recommendations for the Food Industries

- Increasing governmental support to the existing food industries and facilitate the establishment of new ones in form of tax cuts, export subsidies and reduction of the bureaucratic measures which hinder the production and export activities.
- Encouraging the practice of contracted farming of fruits & vegetables intended for processing.
- Encouraging the use of automation, computerization of factories and other up-to date technologies.
- Establishing a Food Processing and Nutrition Institute for training of intermediate- skilled workers in the food industries to acquire the needed technical skills in the various areas of food technology. The institute can be a major research center to solve the problems outlined in this document.
- Encouraging innovation and entrepreneurship in the area of food technology including production of ingredients and additives from local sources.

Recommendations for Food and Nutrition

- Promotion of education on nutrition and food safety among citizens, through the media, schools, universities, and other institutes.
- Raising awareness on the concepts of Food Science among those who deal with food security: either through workshops on nutrition in social protection programs.
- Starting internship program for graduated food scientists and nutritionists.
- Starting a specialized peer reviewed scientific journal for publishing the work of the local researchers.
- Encouraging applied research in the areas of Food Science and Human Nutrition.
- Use of food-based dietary guidelines (FBDG) aiming to educate people in selecting healthy foods.
- Focus on traditional foods including wild edible plants, since such foods constitute part of the cultural food pattern and contribute to food security and alleviation of nutrient deficiencies and eventually achievement of good health.
- A review of the existing food commodity subsidies, in light of the increasing prices, is essential with better identification of the most food-insecure and vulnerable families particularly in poverty pockets.
- Extending the school feeding programs to include all of the Education Directorates instead of covering only 32 out of the 42 Directorates, and the inclusion of all primary school children from the 1st to 6th grade.
- Increasing the expenditure on preventive health and food safety since most of expenditure (70%) is on curative health, with focus on infant mortalities which constitute most of child mortalities. Also breast feeding practices are important, since inclusive breast feeding covers low percent of infants.

Urgent Research Needs

- Updated industrial surveys for the food industries sector.
- Studies of the amounts and cost of energy and water use by the different food industries.
- Studies of the food waste at the different stages of production and consumption.
- Studies on the environmental impact of the food industries.
- Studies on impact of school lunch program.
- More research on role of nutrition in combating the high prevalence of chronic non-communicable diseases.
- Continuous monitoring of the food security situation in Jordan.

Suggested Initiatives for Humanitarian Action

- Unify national databases and platforms concerned in distribution of assistance for vulnerable Jordanians and refugees.
- Identify clear and transparent targeting models for the most vulnerable people in Jordan.
- Improve food security through enhancing strategic reserves of key food commodities.
- Preparedness for emergencies and ad-hoc assistance, and planning for long-term preparedness to provide assistance to people in need.
- Policies to enhance and sustain the humanitarian assistance currently provided to the most vulnerable people in Jordan.
- Building resilience of the most vulnerable people in the long-term, through supporting climate change-relevant initiatives.
- Focus on lowering food loss and food waste: for example, more research to be conducted on this front.
- Increase awareness of the importance of balanced consumption, and how to lower food loss and food waste at the household and community levels.
- Adoption of new technologies for food preservation and food processing, to increase long term food stocking.
- Scaling up innovative processes that can enhance efficiency in agriculture production.
- Utilize mobile technology: Develop a mobile application that connects food insecure individuals with local food banks and charities. This app could allow users to search for nearby food banks, schedule pick-ups or deliveries, and receive notifications about available food donations.
- Community Gardens: Encourage the establishment of community gardens in urban areas where food insecurity is prevalent. These gardens could provide fresh produce to those in need, and serve as a community-building activity. Local organizations could provide resources and support for the creation and maintenance of these gardens.

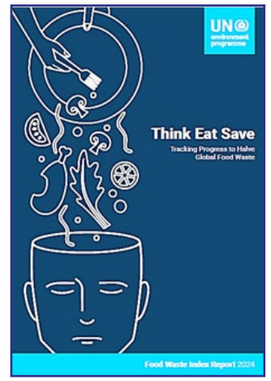
Recommendations for Humanitarian Action

- Apply models of governance, where government decides on the policies and priorities to organize and control the humanitarian sector, and the active stakeholders both national and international lead the operational implementation of a well-functioning humanitarian assistance system in Jordan.
- Operationalization of the above-mentioned suggestion through establishing a national partnership council/committee with participation of public, private and non-governmental sectors.
- The council takes lead on identifying the gaps, developing and programming the initiatives, coordinating the pooling and distribution of funds for humanitarian assistance among all key stakeholders.
- Enhance governance and transparency among all involved institutions. Government role will be facilitation and approving policies, deciding on priorities and regulation of the humanitarian sector in Jordan.

Recommendations

- The development of accessible infrastructure is also vital, supported by new regulations. This infrastructure should facilitate marketing strategy planning tools, enabling more efficient distribution and marketing of agricultural products.
- Improving the food supply and value chains is essential through enhanced infrastructure, logistics, and market access. These efforts will reduce post-harvest losses and strengthen the domestic food system.
- Adopting advanced agricultural technologies, such as precision agriculture and climate-smart agriculture, is recommended to optimize resource use, enhance productivity, and improve climate resilience.
- Promoting innovation and progress, supporting for research and entrepreneurship is necessary.
- A digital interactive platform could facilitate knowledge transfer and provide a national agricultural database for further analysis and development.
- Reducing food waste and post-harvest and agricultural input losses by improving storage, handling, and processing practices.
- Adopting of efficient irrigation systems and water management practices will increase crop productivity and water use efficiency.
- Conserving biodiversity is crucial. Initiatives should focus on rehabilitating rangelands and reducing reliance on imported fodder. Promoting afforestation and implementing agricultural practices such as multi-cropping systems and agroforestry can contribute to biodiversity conservation and sustainable land and water use.
- Implementing drought preparedness measures to protect biodiversity. These measures include the rehabilitation of rangelands, sustainable land management practices, and the establishment of protected areas for biodiversity conservation. By preserving and restoring habitats, the resilience of plant and animal species can be enhanced, enabling them to better withstand the impacts of drought.
- Promoting water-efficient agricultural practices, such as precision irrigation techniques, also helps mitigate the effects of drought on biodiversity by reducing water wastage and ensuring efficient water use. In addition, raising awareness among local communities about the importance of biodiversity and engaging them in conservation efforts fosters a sense of responsibility and ownership. Through these proactive strategies, Jordan can enhance ecosystem resilience, safeguard biodiversity, and mitigate the negative consequences of drought on the natural environment.
- Governmental support for existing and new food industries is essential to enhance the sector. Measures such as tax cuts, export subsidies, and reducing bureaucratic obstacles can encourage growth and competitiveness. Promoting the use of automation, computerization, and modern technologies will improve productivity, reduce costs, and enhance competitiveness.
- Establishing a Food Processing and Nutrition Institute can provide training for intermediate-skilled workers in the food industry, with a focus on preserving cultural food patterns, improving food security, supporting strategic agricultural products: olive and olive oil, tomatoes, dates, grapes, and figs, and addressing nutrient deficiencies.
- Reviewing existing food commodity subsidies and providing targeted support to the most foodinsecure and vulnerable families, particularly in poverty-stricken areas, is crucial for ensuring equitable access to food. Lastly, implementing governance models where the government sets policies and priorities while active stakeholders lead the operational implementation of a well -functioning humanitarian assistance system will foster collaboration, transparency, and effective coordination in ensuring food security.
- Adopting these recommendations, Jordan can enhance agricultural productivity, mitigate the impact of climate change, reduce dependency on imports, and promote a secure and sustainable food future. Collaboration among the government, stakeholders, and the international community is crucial to achieving these goals and ensuring a resilient food and agricultural sector.

Food Waste and Loss in Jordan



- The Food and Agriculture Organization (FAO) highlights that approximately onethird of the world›s food is wasted annually, amounting to 1.3 billion tons and nearly one trillion US dollars. This waste significantly contributes to greenhouse gas emissions, making food waste a major contributor to climate change.
- Food waste in Jordan has doubled over the past two decades.
- It has been estimated at 101 kg per person each year in Jordan, (Food Waste Index, UNEP, 2024).
- The total amount of food wasted in Jordan could feed 1.5 million people for a whole year.
- At the level of food loss, it has been estimated that 22% of all locally produced fruit and vegetables are lost along the various nodes of the supply chain.
- 33% of the country's wheat supply is either lost or wasted.
- The agricultural waste is included in the Waste Management Framework Law (No. 16, 2020).

Food Waste and Loss: Proposed Initiatives

- Survey all food industry establishments to estimate food waste in order to promote cleaner production principles within the sector, including utilizing food by-products.
- Enhance SCP and CE in food industry across the value chain, by:
  - Conducting surveys to estimate food waste, enhancing cleaner production principles, including by-products.
  - Establishment of Key Performance Indicators (KPIs) and guide on reducing food waste by applying Resource Efficiency and Cleaner Production (RECP) principles.
- National food waste index: Focused on a structured approach to food waste reduction, including conducting field studies to assess food waste in restaurants and hotels and establishing a comprehensive database for food waste in Jordan.
- National incubator among food value chain: Launch hackathons to encourage youth initiatives in reducing food loss and waste and promote innovated agricultural practices.
- National legislative framework for food waste reduction: Adjust policies and enforce commitments, include awareness requirements for licensing, and consider the type of transported goods in transportation regulations due to their varying spoilage sensitivities.
- Food waste management infrastructure: This involves qualifying service providers who can manage food waste, especially from the hospitality sector, installing special equipment for food waste treatment like waste digesters, and developing infrastructure to support household and industrial food waste management.

WEFE Nexus

The Water, Energy, Food, and Environment (WEFE) Nexus approach provides a comprehensive framework for addressing the interconnected challenges faced by Jordan›s food and agricultural sector. Adopting this approach effectively enhances food security and mitigates the complex challenges. This policy brief, based on recent statistics, national and international reports, as well as consultations with agricultural and food sector stakeholders, aims to address sector challenges and provide feasible recommendations achievable through national-level projects.

Food Security Panel Discussion Emerging Technologies in Food Supply Chains

Moderator:
Dr. Fadel El Zubi, Senior Strategy Advisor, FAO

Panelists:

- **Eng. Belal Al-Hafnawi**
  Commissioner, Telecommunications Regulatory Commission
- **Dr. Jafar Al-Qudah**
  Advisor to the General Manager, Jordan Food and Drug Administration
- **Dr. Rida Shibli**
  President of Jordan Society for Scientific Research, Entrepreneurship, and Creativity
- **Dr. Rima Mashal**
  Head of Nutrition and Food Technology Department, The University of Jordan
- **Eng. Saeed Al Masri**
  General Director, Khairat Belady Company

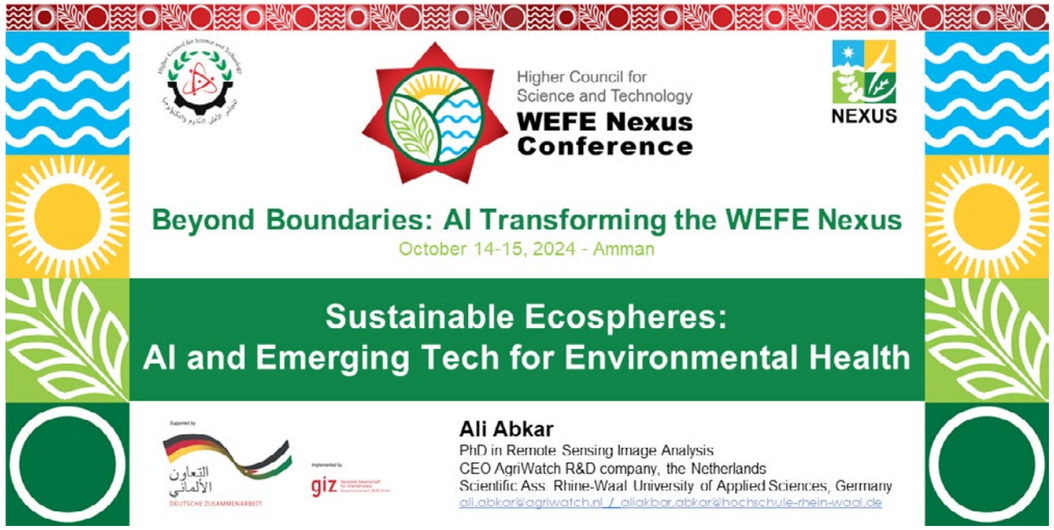
Session 4

ECOSPHERE CLIMATE

Climate Change Keynote Speaker

Dr. Ali Abkar

Managing Director, AgriWatch BV, Netherlands



Structure

- **Introduction**: Sustainable Integrated Management for a Resource-efficient Jordan.
- **Needs based on CCR:** Knowledge/Skills/Products/WEFE-Sector to inspire problem-solving skills, active citizenship, and responsible engagement.
- **Analysis of (new sensor) data:** The WEFE can be quantified.
- **Methods & Tools:** AI, machine learning, segmentation, pattern recognition, feature classification.
- **Examples and Case Studies:** NexusWatch, Drought Monitoring, AgroTec, SAHs, TERRATECH, ECOLUTION, INHABITAT.
- **Conclusion:** Integrated AI and emerging Tech is essential for sustainable ecosphere.

Introduction

- AI and emerging technologies are transforming environmental monitoring:

  »Remote Sensing data (satellite, drone, IoT),
  »GIS data (maps).

  } **Geo-ICT**

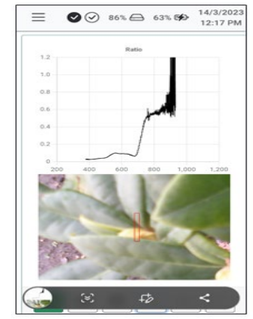
- They offer innovative solutions for sustainable ecospheres, ensuring resourceefficiency and ecosystem resilience.

Definitions

- **Remote Sensing (RS) is**
- **Data acquisition by RS devices that are not in physical contact with the** object, area, or phenomenon under investigation;
  + **Data interpretation** of data/images to acquire meaningful information

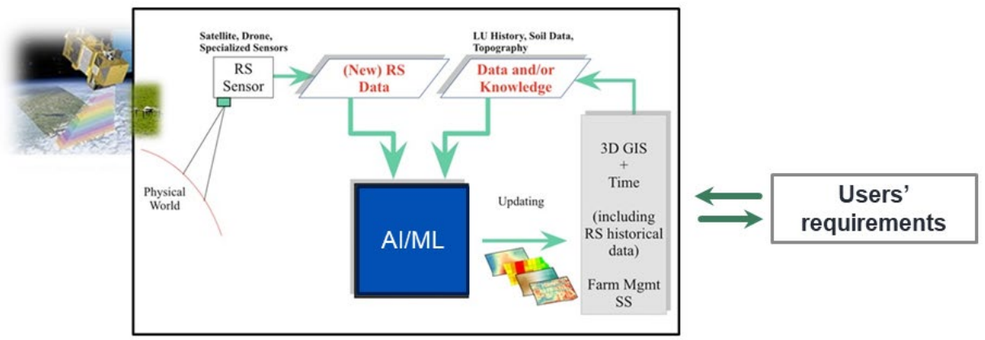
RS: Info from Satellite/Drone/IoT sensor data
- Quality of info?
- Utility of info?

Role of AI in Environmental Health



- **AI facilitates precision agriculture and resource management.**
  - To provide relevant information for managing Ag & Envi. objects and processes.
  - Using new sensors and modelling techniques.
- **ML (3D+Time) models predict environmental changes, enabling proactive measures.**
- **Real-time monitoring of ecosystems supports timely interventions.**
- **Knowledge in its various forms is central**
  - Choice of methods, algorithms and parameters.
  - Context-dependent knowledge from hired specialists, users, farmers, and managers.
- **Explicit reporting of uncertainties, combined likelihoods, predicted classes and model parameters**

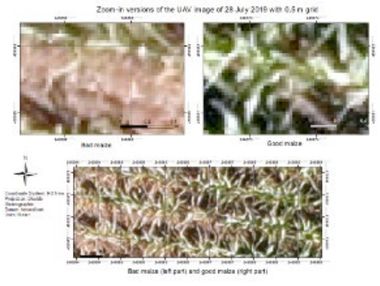
Geo-ICT Image Analysis



Measurement & Control

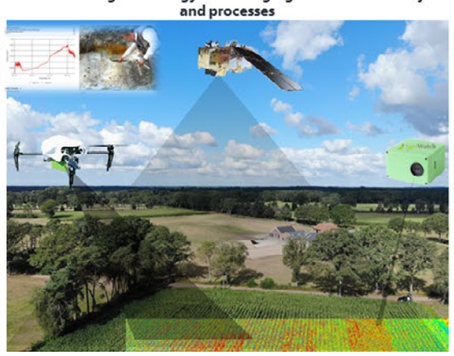
- **Measuring the density of pest/disease in a field using RS/AI (measured with a certain accuracy).**
- **Monitoring crops and their growth and humidity:**
  - which part of the orchards has high/low transpiration, the best time for a single field precision irrigation, reducing the amount of irrigation needed
  - an effective use of methods & crop protection products.
  - Examining fertile trees (on-year) or non-fertile (off-year).

- **Alternative crops/varieties?**
- **Crop tolerance to #HeatStress and #DroughtStress?**



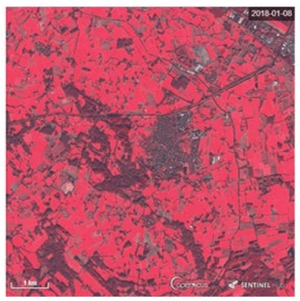
AgriWatch BV
Office address:
World Trade Center Twente
Industrieplein 7553 ,1LL
Hengelo, The Netherlands
www.agriwatch.nl
info@agriwatch.nl

Remote Sensing technology for managing environmental objects and processes



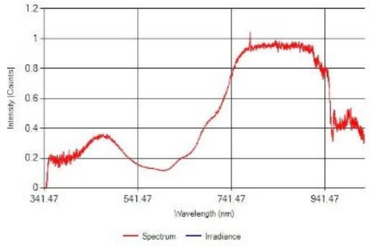
Integrated approach

integrating RS data (satellite, drone, IoT), GIS data (maps), ML, and expert knowledge



Examples and Case Studies:

Some highlights on solutions to the emerging issues of the WEFE nexus



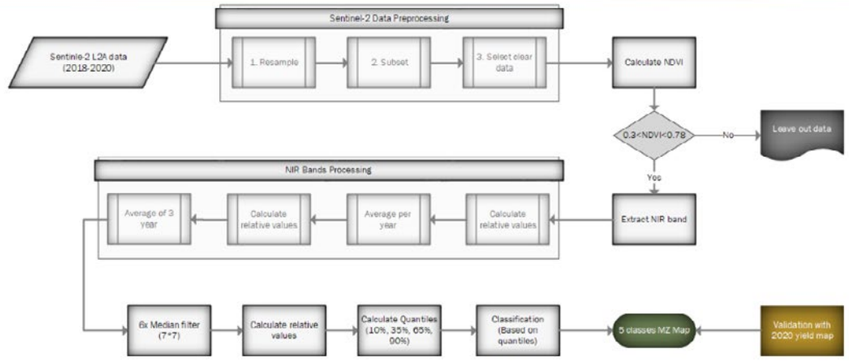
Capacity Building, Internship, and building partnerships

FIE17#: Fertilizing Experiment

SMART AGRI HUBS

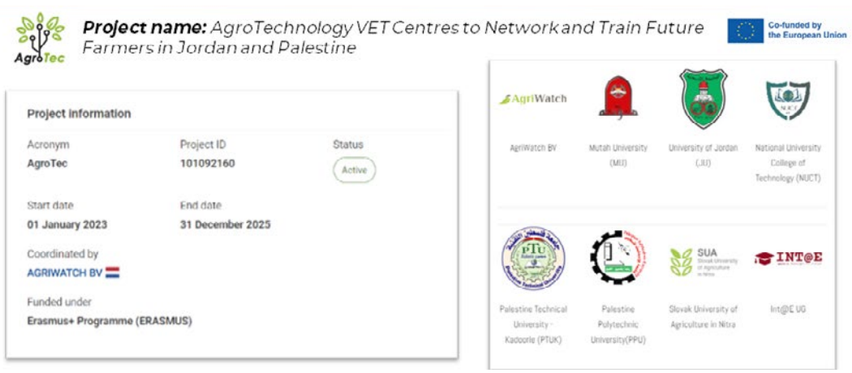
Creating an online Decision Support system for farmers which processes data from sensors and integrates image analyses to improve both yield quantity and quality.
https://www.smartagrihubs.eu/
https://www.smartagrihubs.eu/flagship-innovation-experiment/-17FIE-online-dss-optimise-fertilisers

The flowchart of ML of Geo-ICT data



Delineation of site-specific Zone map for variable rate application of N-fertilization for Wheatfield – Application of integration of sensor packages
ML of RS data

AgroTec project - EU Erasmus+ Skills and Innovation



Results and Impacts

- Established a network of 5 AgroTec centres in 5 Universities in Jordan and Palestine
- 3 staff training in Europe for 20 ToT, Developed 12 innovative VET courses in RS and geospatial technology.
- Established accredited Diploma courses in Smart Agriculture at UJ, NUCT, and PPU
- Highlighted the importance of skills development.
- Increased the use of RS in staff, students, and professionals in JO&PS.
- Increased awareness of smart farming, and the role of Geo-ICT within partner organisations.

AgroTec
AgroTechnology VET Centres to Network and Train Future Farmers in Jordan and Palestine/ AgroTec
ERASMUS+ PROGRAMME - VET
Project #: 101092160
Co-funded by the European Union

AgriWatch **AgroTec Website:** https://nuct.edu.jo/agrotec/

NexusWatch Project (2023-2024)

Earth Observation and Geoinformation Technologies to Foster Water-Energy-Food Nexus Interventions

Funded by the Dutch government
Nuffic- Orange Knowledge Programme (OKP)
Tailor-Made Training Plus (TMT+)
Nuffic Project OKP-TMT+.23/00103

Coordinator: ITC/University of Twente

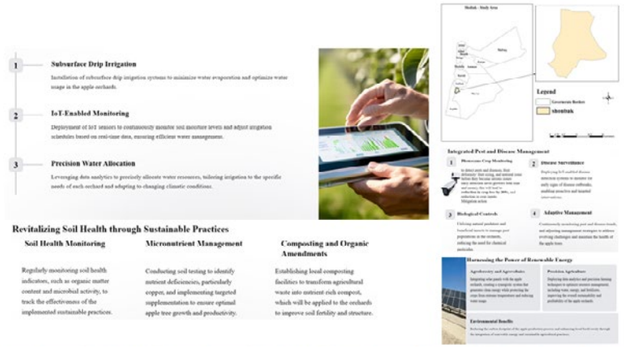
Name: Earth Observation and Geoinformation Technologies to Foster Water-Energy-Food Nexus Interventions
Acronym: NexusWatch
Dutch Partner: ITC Faculty of the University of Twente and AgriWatch company
Jordanian Partners: The University of Jordan, National University College of Technology, Mutah University, National Agricultural Research Center, Future Pioneers for Empowering Communities, and Inter-Islamic Network on Water Resources Development and Management (INWRDAM)

- NexusWatch aims to enhance the knowledge and skills of professionals and organizations active in the water-energy-food nexus through the use of geospatial technologies.
- 20≤n≤50 staff, students, experts, and professionals received training in JO and NL.
- Training and CB: refresher courses, workshops, meetings, internships, lectures, field visits, teamwork

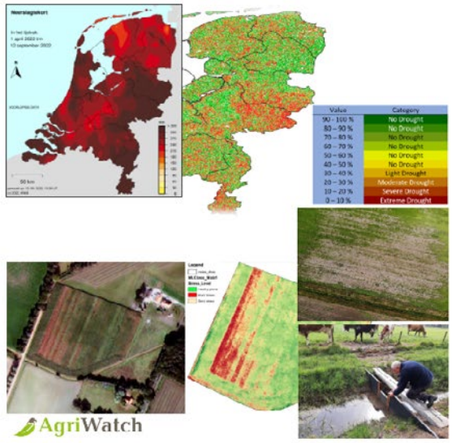
Al-Shara farm was visited by AgriWatch on 13 October 2023, Shobak, Jordan

Case Studies and Teamwork

- Assessing variability and controls of water availability from space: The case of the Jordan Valley
- Impact of the Syrian refugee crisis on land use of Yarmouk basin
- Climate Smart Agroforestry to Enhance Resilience and Productivity
- Enhancing Agricultural Resilience in the Shoubak region



Addressing Water Scarcity through Smart Irrigation



Drought Monitoring

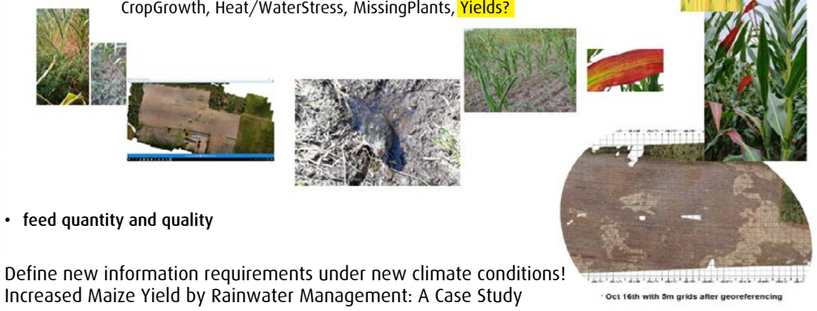
Satellite and drone images for Drought effects monitoringCase of non-irrigated crops in the sandy soils of the Eastern part of NL

September 13th, 2019

Climate Change and Remote&Local Sensing

It can help to understand challenges and scale solutions to larger areas, as well as gain a better regional understanding of challenges/solutions.

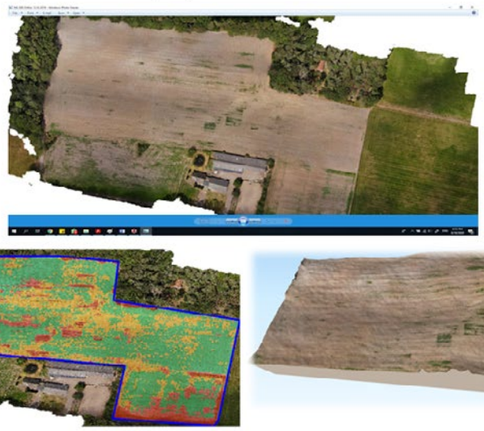
- SandySoil, LessRain, LessInsects, BirdsAttack, Weeds, Fungi, CropGrowth, Heat/WaterStress, MissingPlants, Yields?

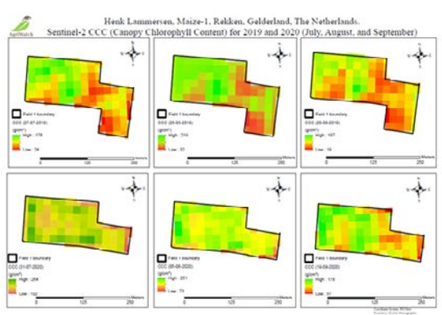


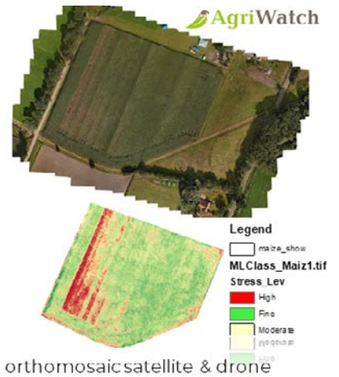
- **feed quantity and quality**

Define new information requirements under new climate conditions!
Increased Maize Yield by Rainwater Management: A Case Study

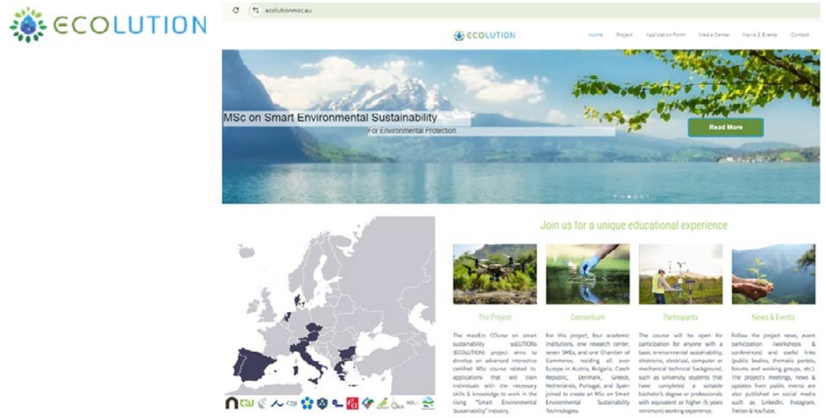
Drone image captured on 12/06/2020 on a maize field in Rekken, NL







Drought Monitoring - orthomosaic satellite & drone data from the Maize trial field and Grassland, trees and bare soil. The Maize plants were under stress after a number of sweltering days in August 2019 and 2020 in Twente region.



Benefit Geo-ICT & Environmental Monitoring

- Geo-ICT provide critical insights into resource consumption, enables efficient use, and promotes sustainable practices through data-driven decision-making. Geo-ICT for:

1) Skills **(AgroTec, NexusWatch)** - fostering digital upskilling and reskilling to equip individuals with the abilities necessary to thrive in the AI age.
    - Geo-ICT specialists in emerging technologies,
    - inclusion of under-represented categories in the Geo-ICT sector (women, migrants).
2) Green **(MedOlive, VETfarm)** - developing digital innovations with a positive climate impact, supporting the twin transition towards green and digital transformation.
    - Precision Farming solutions for site-specific crop management.
3) Society **(AgroSkills)** - the power of digital in fostering social well-being and inclusiveness, to make a positive societal impact through AI (digital solutions).
    - Local and/or regional development.
    - Digital tools for critical responsiveness; Providing timely and practical solutions to counteract natural disasters.
    - More efficient interactions among the scientific community, research institutions and programmes.

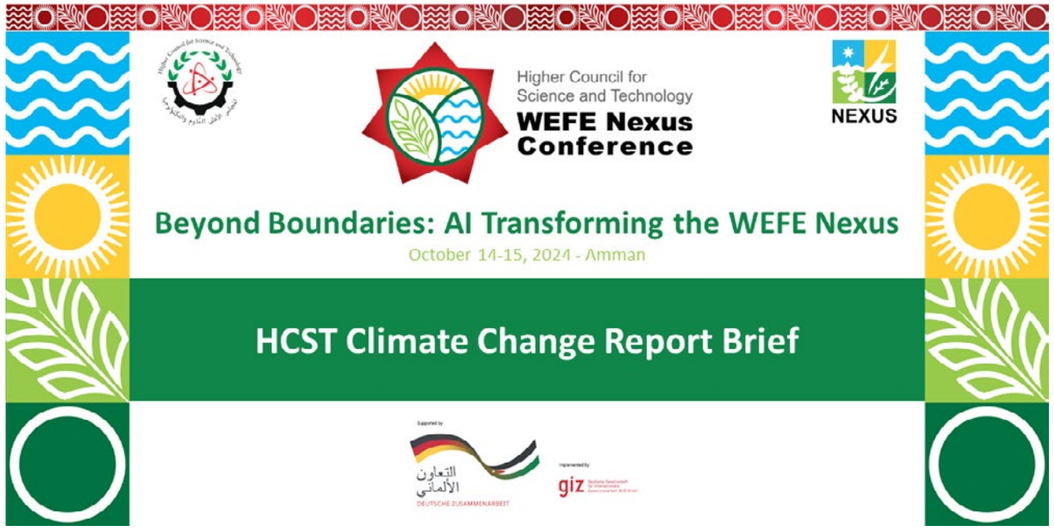
Conclusion

- **Integrating AI and emerging Tech is essential for sustainable ecospheres.**
    - it is important to make AI and emerging Tech available to a wider range of stakeholders.
    - Bird-eye view of the landscape around us using new sensor data!
- **Through Partnerships;** enhanced awareness of climate issues; created poles of excellence (in different areas of climate science and tech); strengthened local institutional capabilities.
- **Benefits:**
    - These innovations drive environmental health and ensure a sustainable future for all.
    - Build resilience and adapt to climate change

HCST Climate Change Sector Report Brief

Eng. Belal Shqarin

Member, Climate Change Sectoral Committee



Committee Members

Committee Members 2023

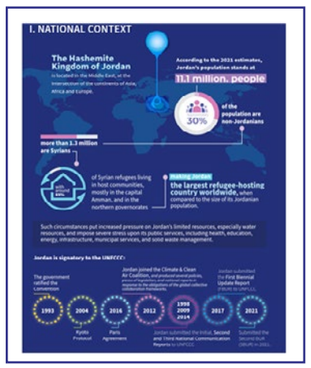
Prof. Jawad Al-Bakri / JU.
Eng. Sami Tarabieh / UNDP
Eng. Belal Shqarin / MoENV

Committee Members 2024

Prof. Saeb Khresat / F.P. JUST Univ.
Dr. Maha AL Zu'bi / IWMI
Eng. Ruba Ajour / RSS
Eng. Belal Shqarin / MoEnv.

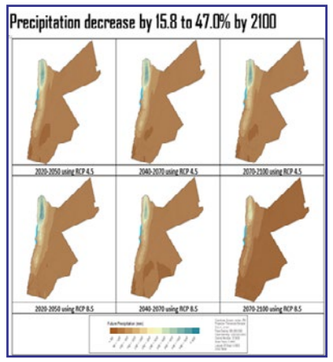
Climate Change Report

- Overview of the climate change challenges in Jordan
- Focus on the water, energy, food, and environment (WEFE) nexus



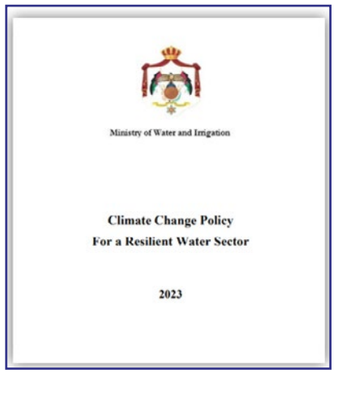
Climate Change Impact on Water Sector

- Jordan's ranking as the 2nd most water-scarce country
- Projected supply reduction (15-18 %) and demand increase
- Water deficit of 835 MCM by 2050



Water Sector Adaptation

- Key adaptation measures: desalination, rainwater harvesting
- Improve efficiency in water use and demand management

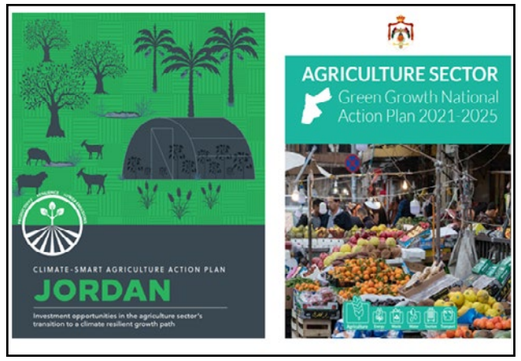


Climate Change Impact on Agriculture

- Jordan's limited arable land (4.5%)
- Projected reductions in crop yields (e.g., olives 20%, feed 15-30 %)
- Increased crop water requirements (12-30 %)

Agricultural Sector Adaptation

- Adaptation technologies: smart irrigation, water-efficient crops
- Stakeholder recommendations: smart agriculture, carbon sequestration

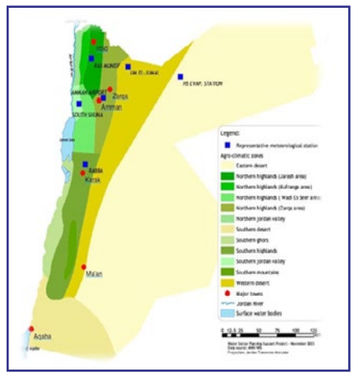


Impact on Energy and Greenhouse Gas (GHG) Emissions

- Energy sector responsible for 79% of Jordan's GHG emissions
- Total GHG emissions projected to reach 54,714 Gg CO2eq by 2050

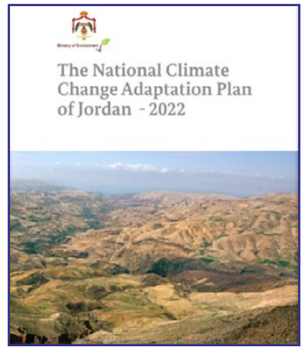
Climate Change Impact on Terrestrial Ecosystems

- Vulnerability of Mediterranean forests and agroforestry to climate change
- Projected reductions in ecosystem resilience and productivity



Adaptation for Terrestrial Ecosystems

- Afforestation projects and ecosystem restoration
- Early warning systems for droughts and flood monitoring



Governance of Climate Change

- Ministry of Environment and Climate Change Directorate's role
- Achievements: National Climate Change Policy, National Adaptation Plan (NAP),
- NDCs, and the Institussional role of all inline Ministries via the By-law

Stakeholder Consultations

- Water sector: desalination, AI for water management
- Agriculture sector: smart systems, carbon sequestration
- Environment sector: early warning systems, ecosystem restoration

Enabling Factors for WEFE Nexus Solutions

- Identified constraints: limited financial resources, lack of specialized staff
- Enabling factors: legal frameworks, technology transfer, and financing

Technology Transfer and Financing

- TAPs (Technology Action Plans) for climate adaptation and mitigation
- Focus on renewable energy, smart systems, capacity building for climate finance access

Gender, Children, and Youth Mainstreaming

- Inclusion of gender and youth in climate policies
- Capacity building in public institutions for gender and youth analysis

Conclusion and Recommendations

- Urgency for integrated climate adaptation measures in WEFE sectors
- Importance of international support, financing, and technology transfer
- Call to action for strengthening governance and stakeholder engagement

Climate Change Panel Discussion Emerging Technologies in Environmental Monitoring and Compliance

Moderator:
Dr. Saeb Khreisat, Faculty of Agriculture, The University of Jordan

Panelists:

- **Dr. Almoayied Assayed**
  Director, Water, Environment and Climate Change Centre, Royal Scientific Society

- **Dr. Fayez A. Abdulla**
  Director, Queen Rania Al-Abdullah Center for Environmental Science and Technology, Jordan University of Sciences and Technology

- **Eng. Mufleh Alalaween**
  Regional Water Advisor, Swiss Agency for Development and Cooperation

- **Dr. Nizar Haddad**
  Director, Innovations & Business Development Fresh Del Monte

- **Eng. Shada El-Sharif**
  Founder & Senior Advisor, Sustain MENA

Session 5

WEFE NEXUS

WEFE Nexus Keynote Speaker

Dr. Bassel Daher

Assistant Director for Sustainable Development
at the Texas A&M Energy Institute, USA

Higher Council for Science and Technology

WEFE Nexus Conference

NEXUS

Beyond Boundaries: AI Transforming the WEFE Nexus

October 14-15, 2024 - Amman

Harnessing AI and IoT for Enhanced WEFE Nexus Security: Challenges, Opportunities, and Future Directions

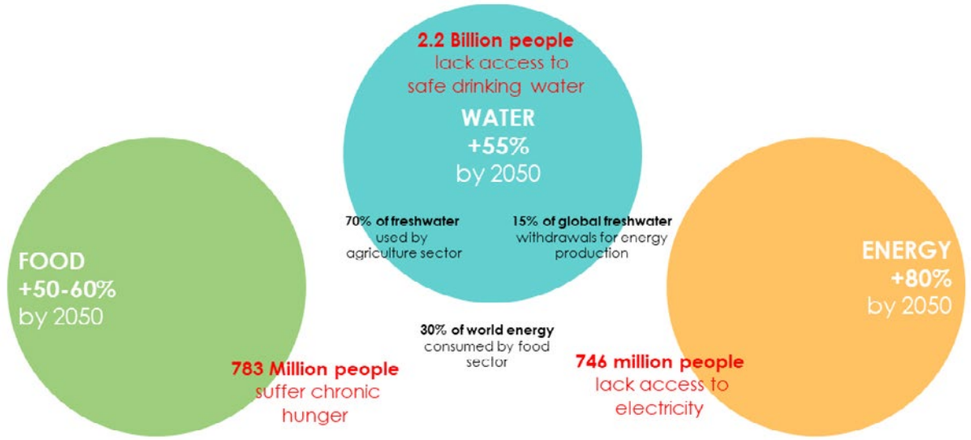
Bassel Daher, Ph.D.

Assistant Director for Sustainable Development | Texas A&M Energy Institute

Research Fellow | Institute for Science, Technology, and Public Policy

Adjunct Assistant Professor | Department of Biological and Agricultural Engineering

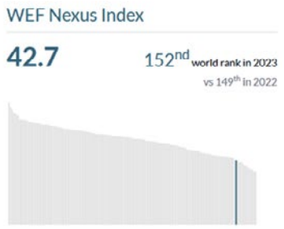
Texas A&M University

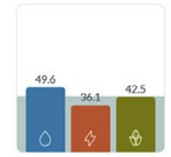


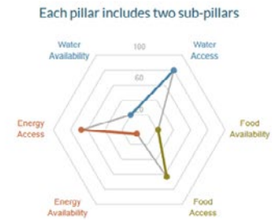
WEF Nexus in Jordan

Jordan in 2023

The Water-Energy-Food (WEF) Nexus Index is a composite indicator that aggregates 21 globally available indicators. The WEF Nexus Index value for Jordan is **42.7**, placing the nation in the **152nd** position for the countries assessed. Jordan has a value of **49.6** for the Water pillar, **36.1** for the Energy pillar and **42.5** for the Food pillar.







Economic Modernization Vision

Growth Drivers to implement the Economic Modernization Vision

Executive Summary **Water**

1 Sector Facts (2021)

GDP	Employment	GDP/employee	NRW* Percentage
JD 0.2bn 0.5% of total	6.8k 0.4% of total	JD 22.3k 17% above avg.	47%

4 Proposed Initiatives

- Reduce NRW* by 2% annually.
- Launch national desalination projects.
- Provide opportunities for private sector investments.
- Improve efficiency of energy use in the water sector, increase the use of renewable energy sources, and implement water dam pumped energy storage projects.
- Improve water efficiency and financial self-sustainability.
- Upgrade water supply/demand management monitoring and control.
- Launch water conservation awareness program.
- Establish climate resilience and sustainable water use.
- Utilize technological solutions for water sustainability program
- Launch National Innovation Center.
- Proper implementation and enforcement of water laws and regulations.
- Establish Nexus Council (Water, Agriculture, Energy and Environment).

* Non-Revenue Water

Seven Strategic Action Areas

(Al-Zu'bi, M.; Daher, B.; Brouziyne, Y.; Laamrani, et al., 2023)

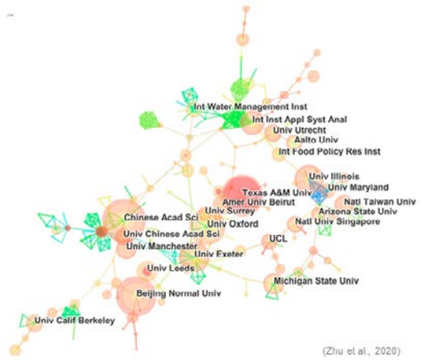
WEFE Nexus Tools

Table 4. The main quantitative models used in food–energy–water nexus.

Method	Model	Publication
Econometrics	Based on existing research or expert judgments	Fu et al. [45] Nerini et al. [86]
Target decision-making	Multicriteria comprehensive evaluation; econometric model	Weitz et al. [87] Huang et al. [71]
Input–output analysis	Input–output model; data envelopment analysis (DEA)	Munoz Castillo et al. [62] Suoyochi ot al. [64]
Life cycle assessment	Life cycle assessment (LCA)	Laurent et al. [66]
Econometric model	Global macro-econometric model	Brouwer et al. [88]
Simulation modeling prediction	Threshold 21; system dynamics model; Integrated model for sustainable development goals (iSDG); Bavesian networks; agent-based model	Colsste et al. [76] Li et al. [72] Bakhshianlamouki et al. [73] Chai et al. [74] Abdel-Aal et al. [75]
Multi-system model	Computable general equilibrium (CGE); long-range energy alternatives planning (LEAP); water evaluation and planning model (WEAP); climate, land-use, energy and water systems (CLEWS); WEF Nexus Tool	Weitz et al. [80] Payet-Burin et al. [81] Zhang et al. [82] Philippidis et al. [83] Olawuyi [84] Welsch et al. [85] Daher and Mohtar [79]

(Zhu et al., 2020)

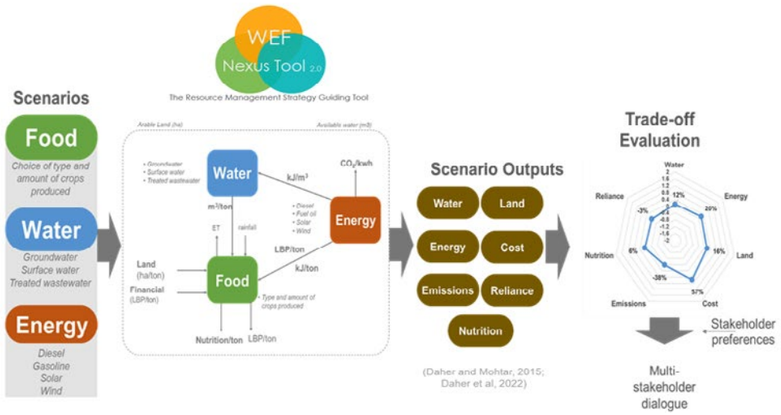
WEFE Nexus Research Networks



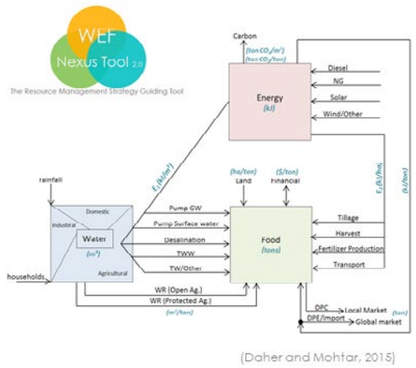
(Zhu et al., 2020)

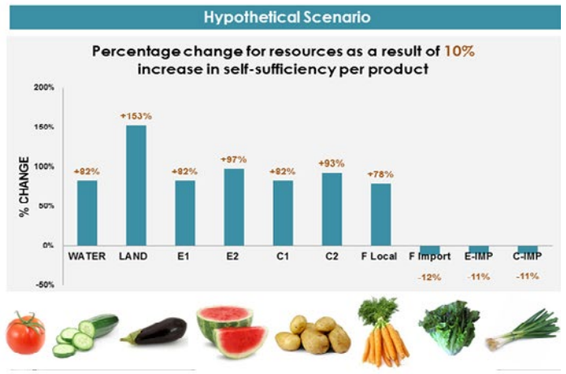
WEFE Nexus Case Studies

WEFE Nexus Analytics

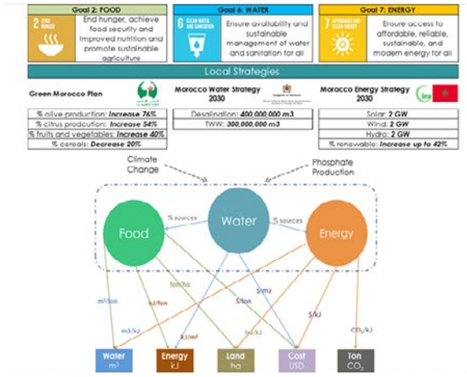


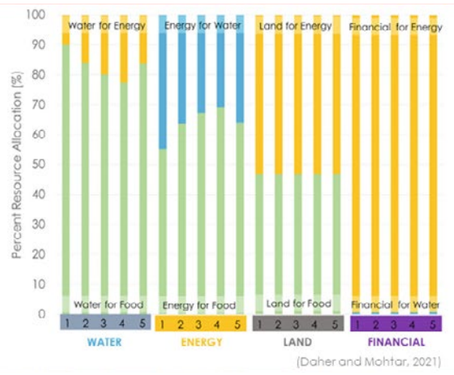
QATAR





MOROCCO



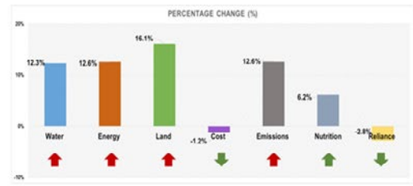


LEBANON

Scenario A: Nutrition-centric

Increase beans (green, broad, dry), lentils, chickpeas and peas (dry, green) to **100% SS**

- **Water:** 80% groundwater, 20% surface water (same as 2017)
- **Energy-Water:** 100% Diesel (same as 2017)
- **Energy-Food:** 70% Diesel, 30% Gasoline (same as 2017)
- **Currency conversion**: 1 USD = 1500 LBP (same as 2017)



(Daher et al, 2022)

Existing Challenges for conducting WEFE Nexus Assessments

DATA AVAILABILITY AND ACCESSIBILITY
- LACK OF COMPREHENSIVE AND RELIABLE DATASETS

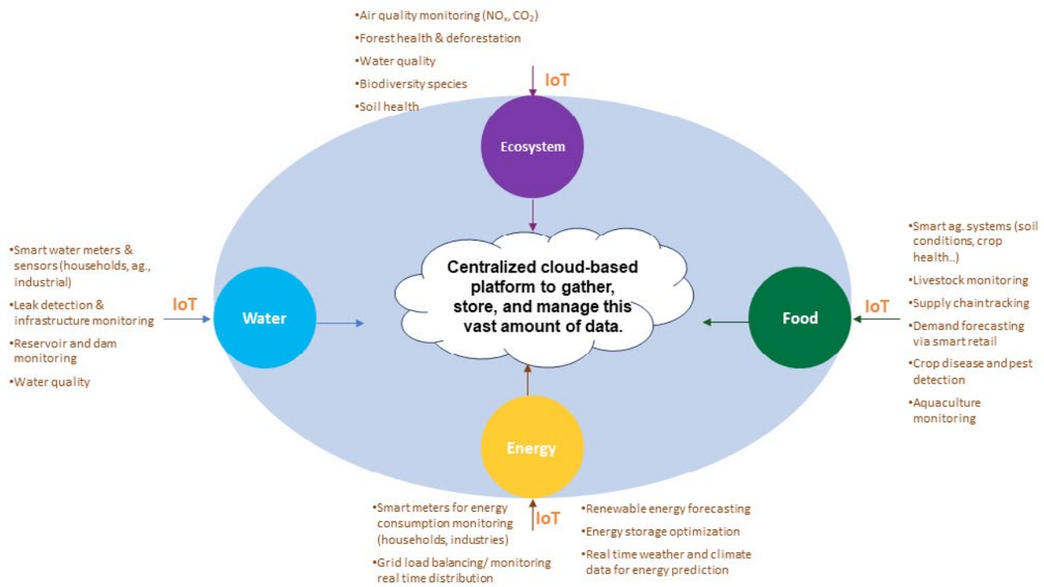
DATA INTEGRATION
- VARYING FORMATS, RESOLUTIONS, AND TEMPORAL SCALES

DATA QUALITY AND ACCURACY
- INCONSISTENT, OUTDATED, OR POOR-QUALITY DATA CAN UNDERMINE THE RELIABILITY;
- PARTICULARLY PROBLEMATIC WHEN USING PROXIES OR EXTRAPOLATING DATA FROM INCOMPLETE DATASETS

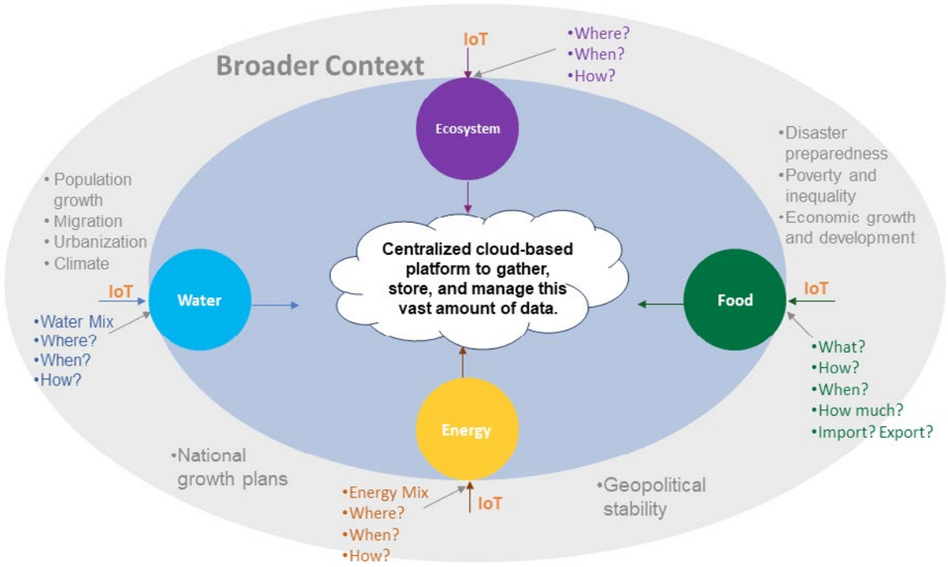
DATA SHARING AND GOVERNANCE
- INSTITUTIONAL BARRIERS TO DATA SHARING
- DATA OWNERSHIP CAN LIMIT ACCESS TO NECESSARY DATASETS ACROSS SECTORS

DISCONNECT BETWEEN DATA USERS AND DATA PRODUCERS
- DISCONNECT BETWEEN COLLECTED DATA AND EVIDENCE NEEDED FOR DECISION MAKING

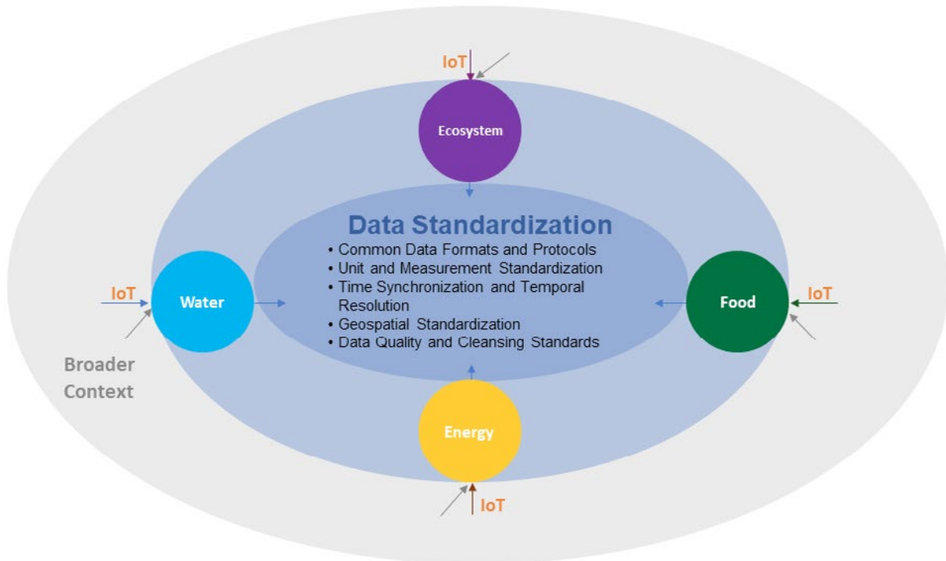
IoT as a Data collection Enabler



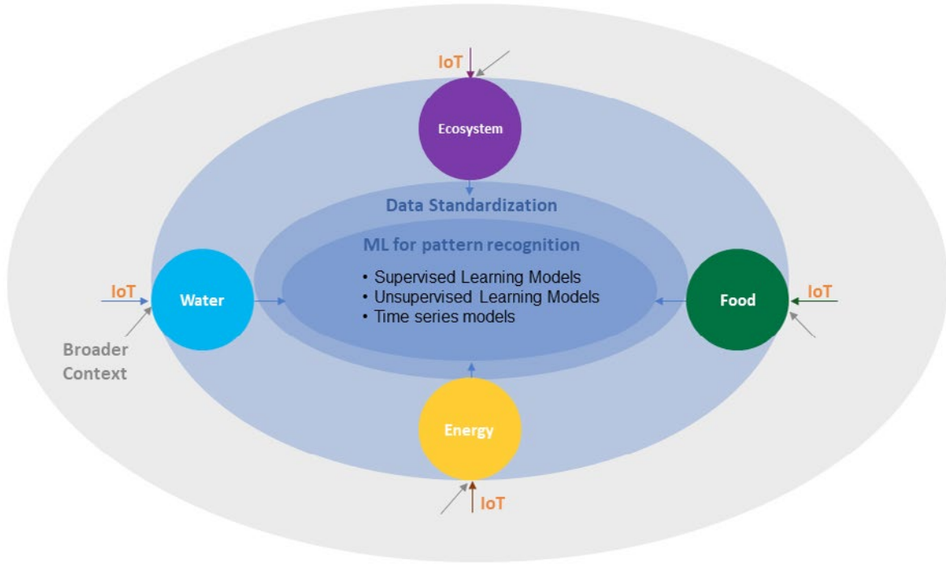
Broader Context



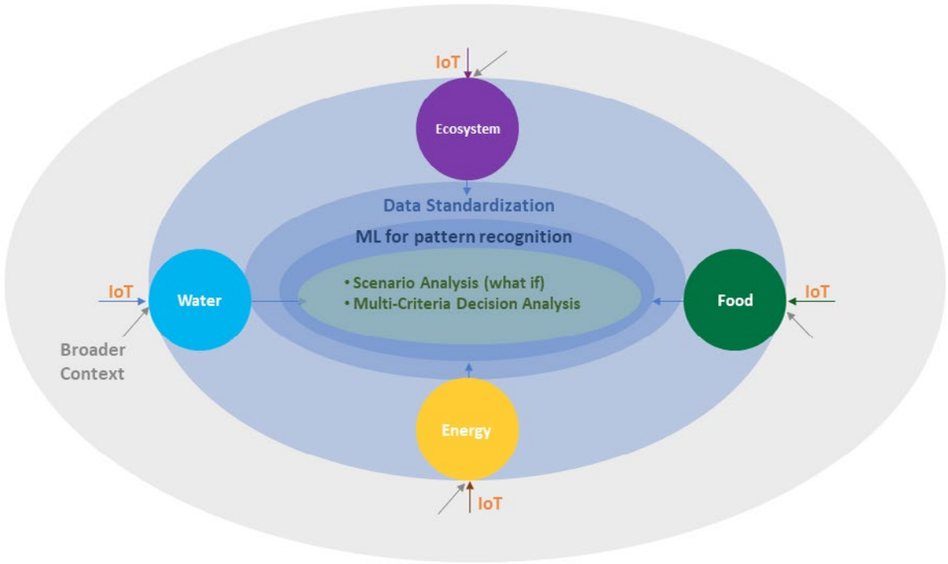
Data Standardization



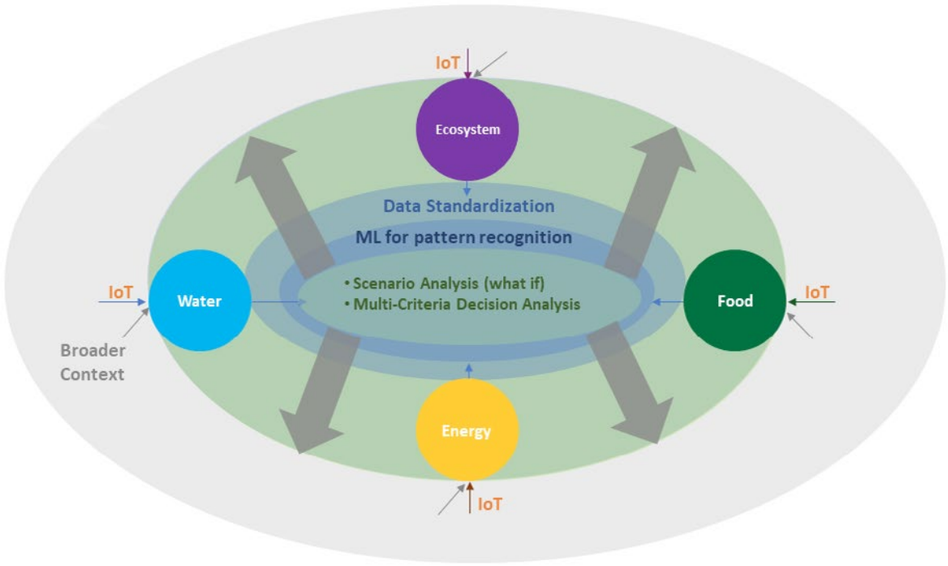
Machine Learning for pattern recognition



Scenario Analysis and Assessment



Cross-sectoral analysis while addressing data sharing challenge



Remaining Challenges and Considerations

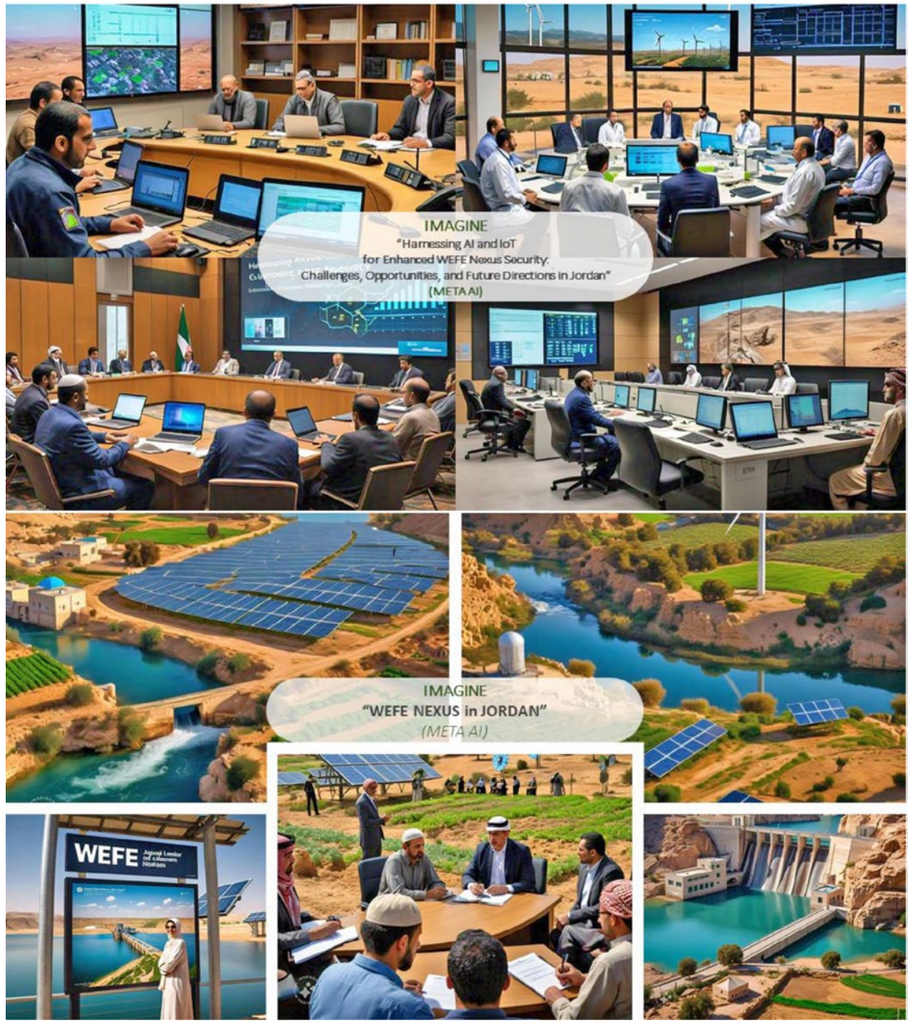
Challenges in **harmonizing multi-sectoral data** for AI analysis

Lack of **technical expertise in AI** and **domain-specific knowledge in WEFE systems**

High computational requirements and **infrastructure limitations**

Data privacy and **governance issues**, especially in politically sensitive regions

Resistance to adoption of AI solutions in traditional governance & resource management frameworks

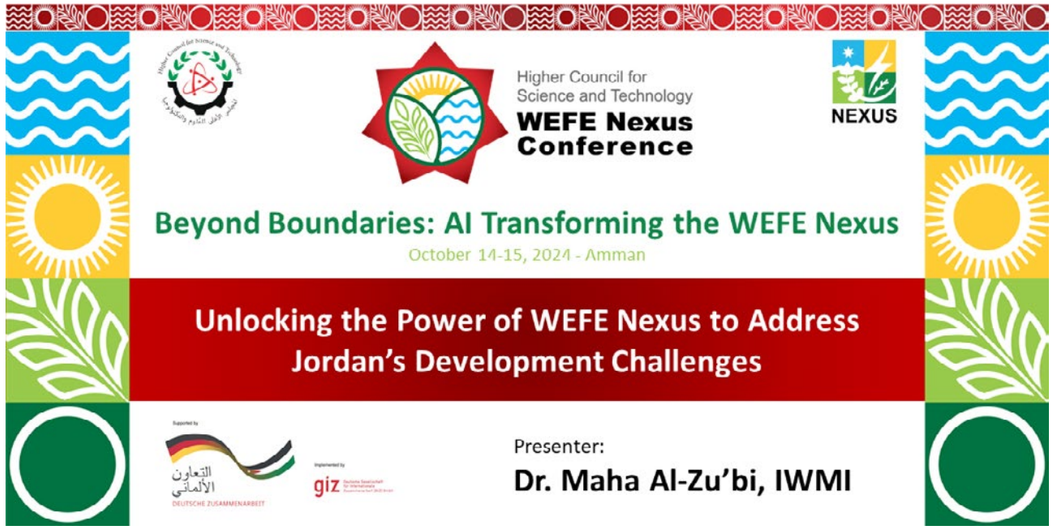


Open Research Questions

1. How can data from diverse IoT sensors across water, energy, food, and ecosystem sectors be effectively standardized and harmonized to enable meaningful crosssectoral AI-driven analysis?
2. How can machine learning be used to uncover causal relationships rather than just correlations between sectors?
3. What role can IoT-driven predictive models play in enabling early intervention strategies for resource conservation in ecosystems under climate stress?
4. What visualization techniques can enhance the interpretability of AI-driven insights, making them more accessible for policymakers, local communities, and sectoral decision makers?
5. What are the ethical and governance challenges of implementing AI-driven WEFE Nexus management platforms in regions with varying levels of digital infrastructure?
6. How can data privacy and security be maintained in IoT-based WEFE systems, ensuring responsible use of AI for resource management without compromising individual or community rights?
7. How can AI and IoT be leveraged to address equity and access in WEFE nexus solutions, particularly in low-resource or developing regions?

HCST WEFE NEXUS Report Brief

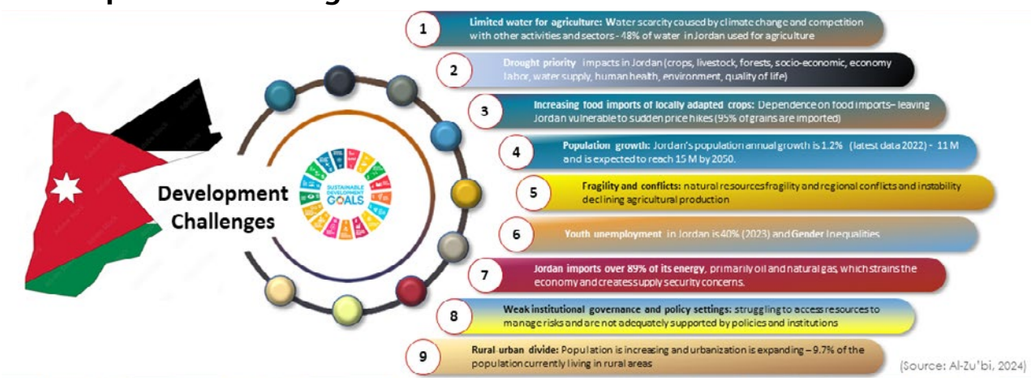
Dr. Maha Al-Zubi
WEFE Nexus Committee



Technical Committee Members/Report Authors:

H.E Professor Mahmud Duwayri | H.E Professor Mohammad Shatanawi | Dr. Jawad Al-Bakri | Eng. Walid Shahin | Dr. Maha Al-Zu'bi

Development Challenges



(Source: Al-Zu'bi, 2024)

WEFE Current Situation: Water Resources

- **Severe Water Scarcity:** Jordan faces extreme water scarcity. In 2021, the renewable freshwater share dropped to 68 m^3 per capita.
- **Rainfall and Water Loss:** Despite receiving 8.2 billion m^3 of annual rainfall, about 75% (6.2 billion m^3) is lost to evaporation, leaving only 2 billion m^3 for blue water and green water (rain-fed agriculture, forests, and pastures).
- **Fluctuating Water Resources:** Jordan's renewable water resources are estimated at 900 million m^3 per year, with surface water and groundwater contributions. However, shared water agreements, such as the Yarmouk River allocation, have not been met, with actual flows reduced to 70-100 million m^3, highlighting the challenges in securing consistent water supplies.
- **Declining Surface Water Availability:** Jordan›s surface water resources have steadily decreased, from 340 million m^3 in 2019 to 308 million m^3 in 2022. Despite having 17 dams with a combined capacity of 310 million m^3, they are generally filled to only 40%-60% capacity in recent years.
- **Over-extraction of Groundwater:** In 2021, groundwater extraction reached 618 million m^3, surpassing the safe yield by 146%, contributing to long-term water sustainability concerns. Additional water resources come from fossil aquifers (143 million m^3) and desalinated brackish aquifers (75 million m^3).
- **Desalination as a Future Solution:** While current desalination efforts are limited, producing only around 7 million m^3 annually, Jordan is developing the Aqaba-Amman Water Desalination and Conveyance Project, expected to provide 300 million m^3 per year, offering a significant boost to the country›s water supply.

WEFE Current Situation: Energy Resources

- **Heavy Reliance on Energy Imports:** Jordan imports over 89% of its energy, primarily oil and natural gas, which strains the economy and creates supply security concerns. The Energy Master Strategy 2020-2030 aims to diversify the energy mix, increase local resources, and reduce import dependency.
- **Growth in Renewable Energy:** Jordan has made significant progress in renewable energy, with its share in electricity generation rising from less than 1% in 2014 to 27.4% in 2022. The target is 31% by 2030, with MEMR aiming for 50%. Solar and wind installations have driven this growth.
- **Challenges and Energy Sector Debt:** The sector faces technical and financial challenges, including high debts exceeding 5 billion JOD for NEPCO due to reliance on expensive oil after the Egyptian gas cutoff (2011-2015). Additionally, integrating renewables into the grid presents operational and capacity issues, with high transmission losses.

WEFE Current Situation: Agriculture (Food)

- **Agricultural Ecosystem Pressures:** Jordan›s agriculture relies on three ecosystems—irrigated, rainfed, and Badia—each facing pressures like water scarcity, overexploitation, climate change, and land degradation, threatening their sustainability.
- **Water Use in Irrigated Agriculture:** Irrigated agriculture, concentrated in the Jordan Valley and highlands, uses about 534.4 million m^3 of water annually, heavily dependent on groundwater and treated wastewater. Water shortages and declining water quality pose risks to productivity.
- **Challenges in Badia and Rainfed Agriculture:** The Badia, covering 93% of Jordan›s area, and rainfed agriculture are both hindered by poor ecosystem management, overgrazing, soil erosion, and high evaporation rates, resulting in significant water loss and low agricultural sustainability.

WEFE Current Situation: Ecosystem (Environment)

- **Degradation of Natural Ecosystems:** Water scarcity in Jordan leads to the overexploitation of groundwater and surface water resources, causing the degradation of wetlands, rivers, and aquifers. This depletion reduces biodiversity, disrupts natural habitats, and accelerates desertification, particularly in fragile ecosystems like the Jordan Valley and the Badia.
- **Energy-Intensive Water Solutions:** The need for energyintensive solutions like desalination and wastewater treatment to address water shortages increases Jordan›s energy demand. This reliance on fossil fuels for energy further contributes to air pollution and greenhouse gas emissions, exacerbating climate change and putting additional stress on Jordan›s already vulnerable environment.
- **Unsustainable Agricultural Practices:** Food scarcity, driven by water and energy shortages, pressures farmers to adopt unsustainable agricultural practices, such as overirrigation and reliance on treated wastewater. These practices lead to soil salinization, nutrient depletion, and land degradation, reducing the long-term productivity and ecological balance of agricultural lands.

King Talal Dam

WEFE Context: Jordan

- **Jordan faces extreme water scarcity**. In 2021, the renewable freshwater share dropped to 68 m^3 per capita.
- **Agriculture** stands as the largest consumer of water resources, accounting for roughly 48% of the country's total water usage.
- The **water sector** in Jordan consumes approximately 14% of the nation›s total electrical energy consumption for activities such as pumping, distributing, treating, and managing water and wastewater.
- **Surface and Groundwater depletion has adverse effects on ecosystems,** resulting in land degradation, loss of biodiversity, and desertification

WEFE Current Situation: Agriculture (Food)

- **Water-Energy Interdependence:** Water and energy are critical and interconnected resources. Rapid population growth and industrialization have heightened the demand for both, exacerbating Jordan›s severe water scarcity and heavy reliance on imported energy, which significantly impacts the country›s economy and resource management.
- **Energy Costs and Desalination:** In Jordan, the high cost of energy, particularly for water pumping and desalination, poses a significant challenge. Desalination, essential for meeting water demands, is energy-intensive and contributes to greenhouse gas emissions. Energy costs account for a substantial portion of water expenses, highlighting the need for costeffective and sustainable solutions.
- **Renewable Energy and Projects:** Jordan is increasing its share of renewable energy, aiming to reach 31% by 2030 in electricity generation and potentially 50% by 2030. The Aqaba–Amman Water Desalination and Conveyance Project (AAWDC) and the Water- Energy Nexus Committee›s efforts to integrate renewable energy solutions and enhance water and energy efficiency are critical for addressing water shortages and improving sustainability.

Water- Food Nexus

- **Economic Importance and Water Demand:** Jordan›s agri-food sector is vital for income and employment, contributing significantly to the economy. However, agriculture is the largest water user, creating pressure on limited water resources and necessitating efficient water management to support food security.
- **Food Security and Imports:** Jordan imports a large portion of its staple food, exposing it to global price fluctuations. Despite low self-sufficiency in staple crops, Jordan maintains a high level of food security, though structural and economic challenges, including high poverty and unemployment rates, impact food security.
- **Sustainable Agriculture and Water Use:** Climate change and overuse of water resources threaten Jordan's water security and food production. Urgent reforms are needed in irrigation practices and crop selection to reduce water usage and enhance productivity. Effective governance and integrated management of water and agriculture are crucial for ensuring sustainability and addressing conflicting demands.

WEF- Climate Change Nexus

- **Climate Change Impact:** Jordan will face more severe challenges in managing water, energy, and food resources due to climate change, with expected decreases in precipitation and increases in temperatures, leading to more frequent and intense droughts and extreme weather events.
- **Agricultural Stress:** Reduced water availability will significantly impact agriculture, particularly in areas dependent on irrigation, exacerbating the need for energy and increasing greenhouse gas emissions.
- **Feedback Loop:** The interplay between climate change, water, energy, and food demands will create a feedback loop, amplifying socio-economic and sustainability challenges in Jordan and the broader region.

Why Should Jordan Adopt a WEFE Nexus Approach?

- **Increase Resource Use Efficiency:** The WEFE approach enhances resource management by identifying interconnections and reducing waste, ensuring optimal use of Jordan's limited water, energy, and agricultural resources.
- **Enhance Policy Coherence:** A holistic WEFE approach allows for better policy alignment across sectors, reducing conflicts and duplication, and enabling more unified responses to socio-economic and environmental challenges.
- **Strengthen Resource Allocation and Security:** By strategically allocating resources based on interdependencies, the WEFE nexus helps balance competing demands, improving national security in water, energy, and food supplies.
- **Reduce Trade-offs:** Managing resources through the WEFE framework minimizes sectoral compromises, allowing Jordan to make decisions that support long-term sustainability.
- **Build Synergies and Improve Governance:** The WEFE approach encourages crosssectoral collaboration, improving governance and promoting transparency, accountability, and resilience in resource management.

Nexus Planning, Policies and Governance in Jordan

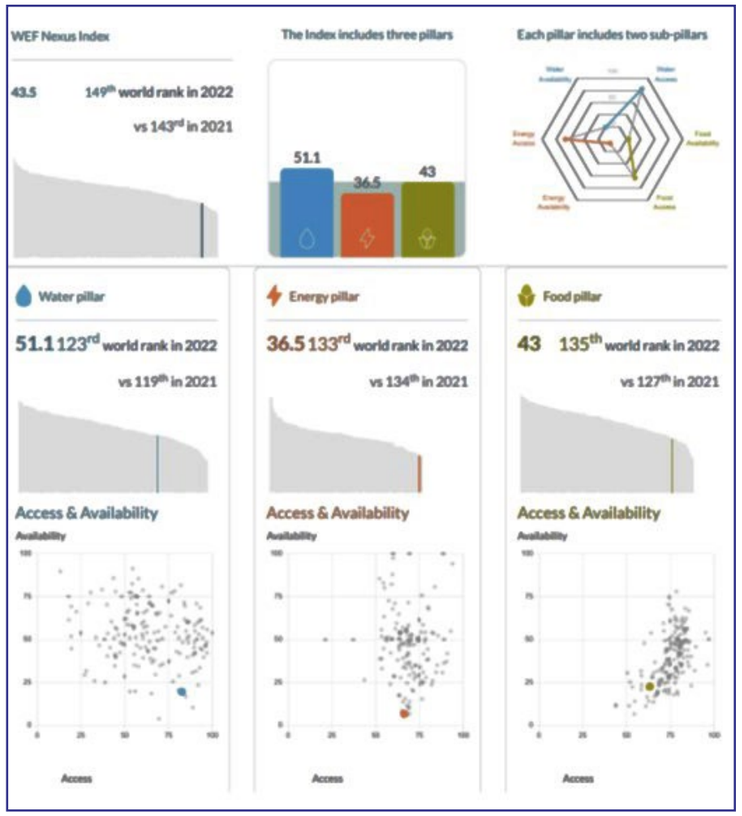
- **Development Challenges and Resource Pressures:** The Government of Jordan (GoJ) faces significant challenges in achieving long-term development goals due to urbanization, population growth, unsustainable consumption patterns, and regional instability. These pressures, compounded by global trade and climate change, have shaped Jordan's development policies over the past three decades.
- **Water-Energy-Food Nexus Importance:** Despite the clear interconnections between water, energy, and food resources, the nexus has not been fully addressed in Jordan›s management strategies. However, with rising water scarcity, GoJ has increasingly recognized the importance of integrating these sectors to harness synergies in resource management and planning.
- **Governance and Policy Coordination:** Policy development for water, energy, food, and climate change in Jordan is highly centralized, often leading to conflicting policies and limited public participation. Addressing these challenges requires better cross-sectoral coordination, good governance, and active involvement of stakeholders to ensure sustainable resource management and development.

WEFE Strategic Development in Jordan

- **Water, Energy, and Food Scarcity:** King Abdullah II has consistently highlighted Jordan›s challenges with water, energy, and food scarcity, emphasizing their links to population growth, refugee influx, socio-economic issues, and regional instability. The Climate Refugee Nexus Initiative proposed at COP27 aims to address these interconnected challenges.
- **National Strategies for Resource Management:** The Government of Jordan has launched several national strategies, including the National Energy Strategy (2020-2030), National Water Strategy (2023-2040), and National Food Security Strategy (2021-2030), to reduce foreign fuel dependence, enhance agricultural sustainability, and address water and food security issues through renewable energy, advanced technologies, and efficient resource management.
- **Climate Change Threats and Economic Vision:** Climate change poses significant risks to Jordan›s water and food security, with projections showing reduced rainfall and rising temperatures. Jordan's Economic Modernization Vision (2022-2033) aims to tackle climate change, foster sustainable development, and enhance the country's global competitiveness through green economy initiatives and international investments.

WEF Nexus Index: Jordan

- The WEF Nexus Index is a quantitative measure and representation of country-level WEF security based on 21 water, energy, and food security indicators.
- As of 2022, the WEF Nexus Index value for Jordan is **43.5**, placing the nation in **149th** position among the countries assessed. Jordan has a value of **51.1** for the Water pillar, **36.5** for the Energy pillar and **43** for the Food pillar.
- **Jordan ranks relatively low** in terms of its WEF Nexus index, coming below Egypt (125), Tunisia (109) and Algeria (102). This is due to country's relative low rankings in the three pillars.



Operationalize WEFE Nexus

- **To successfully implement the Water-Energy-Food-Ecosystem (WEFE) Nexus**, policies must be tailored to national contexts, socio-economic conditions, and development priorities.
- **The WEFE strategy** should advance Sustainable Development Goals (SDGs) 2 (zero hunger), 6 (clean water and sanitation), and 7 (affordable and clean energy), while also supporting SDGs 1 (no poverty), 5 (gender equality), 8 (decent work and economic growth), 12 (responsible consumption and production), 13 (climate action), 14 (life below water), and 15 (life on land).
- **Enhancing the national enabling environment for the WEF Nexus is essential**, involving the adoption of transformative approaches such as nexus planning, scenario planning, sustainable food systems, and circular economy practices.
- **Strategic interventions and integrated analysis through analytical tools are crucial for** developing sustainable pathways for resource security, job creation, improved livelihoods, and regional integration.
- **The process must be interactive and inclusive** to tackle development challenges effectively and ensure no one is left behind.

Transition from "Silo" to WEFE Nexus Approach

- **Barriers to Nexus Approach:** Jordan faces multiple barriers to shifting from a siloed to a nexus approach, including financial, technical, legal, capacity, informational, and institutional governance challenges. The entrenched vertical structure of government departments complicates coordination and limits effective integration across sectors.
- **Governance Challenges:** Current governance and institutional mechanisms may be inadequate for supporting the nexus approach. Addressing complex environmental issues requires new skills, tools, capacities, and incentives to overcome challenges such as management complexity, contested methods, and unclear rights and responsibilities.
- **Priority Linkages:** Key WEF linkages in Jordan include water-energy, food-energy, and water-food-climate change. Priorities are water-energy and water-food inter-linkages, which are crucial for addressing Jordan›s resource challenges.
- **Stakeholder Engagement:** Effective implementation of the WEF Nexus requires recognizing and engaging all relevant stakeholders, considering their concerns, and understanding their roles to ensure meaningful participation and implementation.
- **SDG Alignment:** The WEF Nexus approach supports the acceleration of Sustainable Development Goals (SDGs), particularly those related to poverty eradication (SDG1), hunger and food security (SDG2), clean water and sanitation (SDG6), affordable and clean energy (SDG7), responsible production and consumption (SDG12), and climate action (SDG13).
- **Holistic Benefits:** Adopting the WEF Nexus approach promotes resource efficiency, resilience, and sustainability. It helps address complex global challenges, supports integrated strategies for achieving multiple SDGs, and contributes to a more equitable and prosperous future.

Policy Recommendations

- **Mobilize and Scale up Green Investment:** Attract private sector investment in green technologies such as low-carbon energy, smart agriculture.
- **Agricultural Water-Saving Technologies:** Accelerate adoption of water-saving technologies in agriculture through adjusted water and energy tariffs.
- **Irrigation System Modernization:** Upgrade irrigation systems with innovative technologies to combat water scarcity.
- **Incentive and Subsidy Redesign:** Reform subsidies to promote energy efficiency and adoption of solar and water-saving technologies.
- **Cross-Sector Coordination, Database and Monitoring System:** Develop a comprehensive coordination system, cross-sector database to support evidence-based policymaking in water, energy, and food management.
- **R&D Investment in Sustainability:** Increase public and private investment in research and development for sustainable solutions.
- **Capacity Building, Knowledge:** Strengthen capacity within government agencies to implement WEF Nexus management practices.
- **National WEF Nexus Index:** Develop a customized WEF Nexus Index tailored to Jordan's challenges to guide policy and resource management.

Conference Recommendations

Water Sector

- Establish AI and data science applications for water governance and NRW reduction, focusing on practical applications like leak detection, usage analysis, and predictive maintenance.
- Develop a centralized data hub for water quality and quantity monitoring, expanding it to include real-time integration and predictive tools analysis to forecast water availability and planning for regular and drought conditions.
- Conduct comprehensive groundwater studies using advanced modeling with a decisionsupport interface, incorporating social and transboundary aspects for regional needs.
- Drive AI-based research in water management with a focus on energy-efficient desalination and global collaborations. Establish partnerships to foster knowledge exchange and student involvement.
- Evaluate future water sources, including wastewater reuse and desalination, using a scenario-based water budget model that includes cost-benefit analyses for all options.
- Expand training for water sector professionals, partnering with institutions for AI-focused programs and hands-on learning.
- Foster public-private partnerships for water innovation, establishing incubators, competitions, and mentorships for AI-driven solutions in water management.
- Create a comprehensive roadmap for AI integration, including a timeline, responsible parties, and KPIs to track progress in water sector digitalization.

Energy Sector

- Enhance the regulatory framework to encourage competition and facilitate private sector participation in renewable energy.
- Conduct a comprehensive review of the electricity sector to align business models with modern, decentralized structures and promote participation from IPPs and the private sector.
- Support the integration of renewable technologies, emphasizing solar, waste-to-energy, and emerging tech like hydrogen, with a focus on energy efficiency and clean fuels.
- Develop smart grid policies, incorporate IoT and device integration to improve grid efficiency, and adopt a digital twin model for simulations that enhance grid resilience.
- Promote energy storage solutions to stabilize renewable energy, implementing a digital twin and launching pilot projects for decentralized energy systems like PV solar and microgrids.
- Implement smart metering and prepaid billing to align energy demand with supply, supporting better grid management and efficiency.

Food Sector

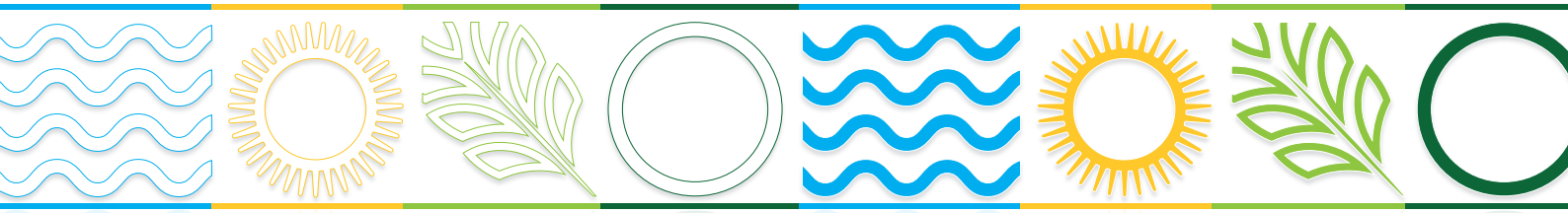
- Incorporate WEFE Nexus and circular economy principles into national policies for sustainability
- Advance sustainable agriculture by promoting precision agriculture, supporting IoT and AI based pilot projects for efficient water use and improved yields, and using treated wastewater.
- Adopt policies to support small-holder farmers.
- Strengthen efforts on food processing and climate-resilient agriculture, emphasizing R&D and partnerships to foster sustainable practices. Continue to strengthen support for the food industry with incentives for export-oriented businesses and link farmers to markets through contract farming initiatives.
- Promote balanced food consumption while fostering community resilience through self-sufficiency and reducing dependence on humanitarian aid.
- Strengthen efforts of reducing food losses and waste through the food chain process.
- Conserve and utilize of biodiversity through working on rehabilitating rangelands. Adopt strategies for strengthening efforts on afforestation.
- Emphasize the role of nutrition in the well being of the populations at different age levels.

Climate Change Sector

- Implement climate-resilient policies in water management, promoting water-saving technologies and deploying WEFE pilot projects to address climate challenges like drought.
- Adapt agricultural practices to climate conditions by promoting water-efficient crops, optimizing irrigation, and initiating climate-focused pilot projects at the community level.
- Scale renewable projects, enhance public transport, and conduct scalable awareness programs through schools to foster community engagement and climate awareness.
- Continue ecosystem restoration efforts and establish early warning systems for environmental monitoring, emphasizing resilience and mitigation in environmental protection policies.
- Strengthen governance with climate-focused units across public institutions, enhancing coordination and participation among stakeholders in climate governance.
- Develop Technology Action Plans (TAPs) to secure climate funding, improve access to finance for climate initiatives, and build national capacity for resource mobilization in climate adaptation and resilience.
- Expand climate education initiatives with “Green Fab Labs” and “Mobile Labs” for hands-on learning, focusing on practical climate science education and community engagement.

WEFE Nexus

- Provide training on WEFE Nexus principles, focusing on IoT, data analytics, and AI applications for integrated resource management and collaboration.
- Mobilize green investments for sustainable technologies, implementing WEFE tools customized for Jordan’s specific conditions and promoting adoption through incentives.
- Establish a centralized system for data exchange across sectors to enable coordinated monitoring, evidence-based decision-making, and impact assessments.
- Create a WEFE Nexus Index specifically for Jordan, incorporating real-time IoT data for dynamic management and policy updates, enhancing resource management responsiveness.



الذكاء الاصطناعي: حلقة الوصل في منظومة المياه والطاقة والغذاء والبيئة

NEXUS

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