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Role of the United Nations Framework Classification for Resources in the delivery of the Sustainable Development Goals

United Nations Framework Classification for Resources supporting the attainment of Sustainable Development Goals

Transforming our world's natural resources: A step change for the United Nations Framework Classification for Resources?

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Summary

The transformative 2030 Agenda for Sustainable Development has inaugurated a new era in global development. This era is marked by a new narrative, substituting the previous orthodoxy, expressed in business process language, of pursuing "economic, social and environmental" gains in equal measure, with a commitment to meeting the needs of two key beneficiaries "people" and "planet" through the common goal of sustainable "prosperity" for all. As a first transformative step, the United Nations Framework Classification for Resources (UNFC) in its current form has incorporated guidelines for applying social and environmental considerations to resource classification and management (ECE/ENERGY/GE.3/2018/3). These guidelines provide the critical social and environmental basis for classification of resources in a manner that allows environmental, social and economic aspects to be in equilibrium. A second such step is proposed in this document, redefining UNFC's core purpose and underlying principles and assumptions according to the Sustainable Development Goals (SDGs).

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I. Introduction

1. The transformative 2030 Agenda for Sustainable Development has inaugurated a new era in global development. This era is marked by a new narrative, substituting the previous orthodoxy, expressed in business process language, of pursuing "economic, social and environmental" gains in equal measure, with a commitment to meeting the needs of two key beneficiaries "people" and "planet" through the common goal of sustainable "prosperity" for all. If this prosperity is to be achieved and shared equitably, the manner in which we, the people, collectively manage and use the natural resources of the planet will be perhaps of all performance indicators the key for measuring our collective attainment of Agenda 2030, otherwise known as the Sustainable Development Goals (SDGs). Why, how, when and where natural resources are discovered, produced, consumed, recovered and reconsumed, and how these actions and decisions affect our climate, will define more than any other activity whether or not we have succeeded.

2. Against this background, the United Nations Framework Classification for Resources (UNFC), whose origins and purposes long predate Agenda 2030, but also Our Common Future (1987), sees no alternative but to transform itself to meet the new purposes it is challenged, but also required, by Agenda 2030 to face. Its task is to offer people – whether organized as member states or commercial enterprises - a balanced, integrated and comprehensive classification and management system for all the natural resources at their disposition. Transformation is nothing new to UNFC, its most recent reinvention of itself being completed in 2009. This next transformation is already under way. Since 2016, UNFC applies to energy, including oil and gas, renewable energy, minerals including nuclear fuel resources; injection projects for the geological storage of CO_2; and anthropogenic resources such as urban landfills, construction and demolition materials and industrial residues and wastes.

3. UNFC is, and will remain, aligned to existing systems such as the Petroleum Resources Management System (PRMS), the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) family of codes for solid minerals and the Oil and Fuel Gas Reserves and Resources Classification of 2013 of the Russian Federation. Meanwhile, alignment of other, typically national or regional, systems to UNFC is well advanced. These include both the Chinese petroleum and mineral systems and systems deployed in Nordic countries (Finland, Norway and Sweden) which have developed locally moderated UNFC guidelines for mineral resources. The African Minerals Development Centre (AMDC) has recently decided to establish a continent-wide system for the management of Africa's oil, gas, mineral and renewable energy endowments, grounded in UNFC but tailored to meet local needs, priorities and circumstances in line with the Africa Mining Vision.

4. As a first transformative step, UNFC in its current form has incorporated guidelines for applying social and environmental considerations to resource classification and management (ECE/ENERGY/GE.3/2018/3). These guidelines provide the critical social and environmental basis for classification of resources in a manner that allows environmental, social and economic aspects to be in equilibrium. A second such step is proposed in this report, redefining UNFC's core purpose and underlying principles and assumptions according to the SDGs.

II. Sustainable Development Goals and UNFC

5. The United Nations 2030 Agenda for Sustainable Development, also known as the Sustainable Development Goals (SDGs), approved by 193 Heads of State in September

2015, "is a plan of action for people, planet and prosperity" whose stated objective is "Transforming Our World"[1]. This is unapologetically transformative phrasing, whereby the adjectival "Triple Bottom Line" (TBL) [1,2] "win/win" triad of "economic, social, and environmental" returns, coined by Elkington in 1994 as a way of describing the potentially profitable relationship between corporate business and sustainable development goals as set out in the 1987 Brundtland Report [3], and which has dominated both United Nations (UN) thinking and its related administrative behaviour since the mid-1990s, is taken up into a new UN triad of substantives, "people, planet and prosperity".

6. This new triad is all the more transformative in that it rearranges the sequence in which the TBL returns are to be measured, placing people ("social") first, planet ("environmental") second and "prosperity" ("economic") third and in such way that is deliberately syllogistic in nature. If people – the planet's human resources - are more justly treated (SDG 16), better educated (SDG 4) and possessed of greater capabilities (SDGs 9 and 11), and if the planet's other – non-human - natural resources are managed in a more sustainable manner (SDG 12), ie as a "non-zero-sum" game, greater prosperity and resilience will be the outcome. Or, simplified, if the tangible resources of people and planet enhance their capacities to meet each other's needs, short- and longer-term, the intangible benefit of increased and sustained prosperity across generations to come will follow. This approach puts a double emphasis on "prosperity", both economic and ethical. As suggested by its etymology – "doing well"[2] in our own generation obliges us likewise "do well" by generations to come by passing through to them the capacity to live as well as or better than use; or, as they might express it in retrospect, "our forebears have enabled us to prosper[3] as we might have hoped they would".

7. However the people-planet-prosperity triad is construed, certainly *a* critical dependency, and perhaps *the* critical dependency for sustained prosperity will be to reappraise the way, and purposes for which, we find, recover, supply, use and reuse our natural resources, both primary and secondary. Claude Levi-Strauss observed that cultures are never more vulnerable than when they lose the ability to challenge their base assumptions [4,5]. The SDGs challenge UNFC to conduct such a review of itself.

III. A step change for UNFC?

8. This discussion note concerns the role that the United Nations Framework Classification for Resources[4] (UNFC) [6] will play in future in framing and guiding the natural resource management life-cycle. It asks whether UNFC as currently written, long predating the UN Agenda 2030, can be applied as is, or with only minor modifications or whether it will require, at least in part, a step change to make it fit for purpose in delivering the SDGs. A classification and management framework for quantifying and progressing natural resources is clearly a necessary tool in the SDG delivery toolbox. What attributes must this tool, and the users of the tool, have or perhaps acquire to demonstrate that it has capabilities sufficient to meet the expectations of resource management raised by the SDGs?

9. It argues that this condition of sufficiency cannot be fully met (a) if UNFC remains exclusively project-based in its core assumptions and methodology, and (b) if the principles

[1] See https://sustainabledevelopment.un.org/post2015/transformingourworld

[2] For the etymology of "prosperity" see https://en.oxforddictionaries.com/definition/prosperity

[3] For the etymology of "prosper" and its derivation from Latin "pro spere" meaning "hope" see https://www.etymonline.com/word/prosper

[4] See https://www.unece.org/energywelcome/unfc-and-resource-classification.html

on which UNFC as a "principles-based" system rest are not reviewed and revised in line with meeting Agenda 2030 goals. Of course, this does not obviate the need for a clear and compelling description of what the resource recovery objectives are, beginning with the evaluation and classification. If the term "project" is retained its definition and semantics will need modification. Alternatively, a new term maybe needed to reflect the change of scope for UNFC.

10. It makes this case not because of past deficiencies or failures in the development and application of UNFC, but rather because what is required of UNFC for the Agenda 2030 determined future is different from the requirements which first gave rise to its creation after World War Two. Preceding and in parallel with the drafting process a number of consultative workshops, meetings and conference calls with contributors and interested parties were held in 2017:

- European Federation of Geologists (EFG)/United Nations Economic Commission for Europe (ECE) Workshop, Brussels, Belgium, 10 February
- International Atomic Energy Agency (IAEA)/ECE Uranium resources consultancy meeting, Geneva, 24-25 April
- Side event "Managing natural resources smartly – a tool to attain the 2030 Sustainable Development Agenda", sixty-seventh session of ECE, Geneva, 26 April
- Panel discussion on SDGs, Expert Group on Resource Classification, eighth session, Geneva, 27 April
- Joint meeting of the UNFC Anthropogenic Resources Working Group and the European Cooperation in Science and Technology (COST) - Mining the European Anthroposphere (MINEA) Project, Geneva, 28 April
- Expert Group on Resource Classification Social and Environmental Considerations Task Force meeting, 14 June
- Joint ECE, Entwicklungsfonds Seltene Metalle (ESM Foundation) and EIT Raw Materials Workshop on Strategic Raw Materials and Sustainable Development at the World Resources Forum 2017, Geneva, 24 October
- Twelfth session of the ECE Group of Experts on Coal Methane, Geneva, 25 October
- Review meeting of the UNFC Anthropogenic Resources Draft Specifications Tutzing, Germany, 15-17 November.

IV. UNFC as transformation agent

11. To enable UNFC to perform adequately as a tool to aid SDG delivery it may need first to transform itself. This transformation entails modifying it such that it encompasses and enables "balanced, integrated and indivisible" approach to the process of recovering value from responsible natural resource management and progression and converting that value into sustainable prosperity, as envisaged by the 2030 Agenda. This transformation takes the properties and attributes of the natural resource eco-system as a whole as the baseline for UNFC. While projects will retain an operational function within this eco-system, sustainability that balances the needs of people and planet in a new Nash-like environmental-economic equilibrium, with equitably-distributed prosperity as the outcome, cannot be achieved unless natural resources are seen as naturally "integrated and indivisible" rather than disaggregated as commodities.

12. If such a step change is necessary to meet the transformational 2030 Agenda's objectives in respect of natural resource management, this note asks "how can this be effected in a manner that sufficiently delivers it?" Will this require simply the modification and optimization of UNFC in its current form, or its radical, and perhaps disruptive, revision, or a combination of both? All resource classification systems now in use, including UNFC and those to which it has been progressively "bridged", long predate Agenda 2030 and none of these were created with the delivery of the SDGs in mind. In some jurisdictions, specific systems are mandated by law, and hence there is no suggestion that any existing system does not remain "necessary", at least for the foreseeable future. But it is equally the case that no existing system is "sufficient" in its current state to meet the needs of SDG delivery and the Paris Agreement. Modification and change are inevitable, but there is no case for change for change's sake. Change must be made according to clear and agreed principles, requirements and objectives, which it is the purpose of this document as relevant to natural resources to elicit.

A. Principles

13. Among the principles that might apply to modifying UNFC is that it express a:

(a) Set of shared values, derived from the ethical "natural justice" position of Agenda 2030, as to how growing prosperity from natural resources is to be achieved;

(b) Transparent provenance and purpose for recovered natural resources with full supply-chain traceability;

(c) Clear, compelling communications plan as to how prosperity from natural resources may be delivered, based on a "map" of immediate, direct and indirect stakeholders;

(d) Commitment to:

(i) Comprehensive and integrated resource recovery

(ii) Valorization (reuse, recycling) of secondary resources/ residuals

(iii) Zero waste;

(e) "Constructive regulation" [7] framework allowing operator, policy-maker, investor and regulator, for the common good, to collaborate on key technology-selection and operational decisions;

(f) Description of how the social licence to operate [8] affects, even determines, successful resource progression and value-add;

(g) Clear and transparent contractual and governance framework;

(h) Policy of equitable distribution of benefits;

(i) Local content policy anchored in building local capabilities and socio-economic, resilience; and

(j) A clear vision of how to foster and apply investment in innovation, such as in "digital mining" – the application of smart, next-generation processing power and Artificial Intelligence (AI) to the optimization and/or disruption of procedures for resource evaluation, recovery and management.

B. Beneficiaries, stakeholders, intangibles and tangibles

14. Agenda 2030 resolves into three key, indivisible elements - people, planet and prosperity. The premise is that if people and planet are in fruitful and equitable equilibrium prosperity will follow. In trying to understand better the equilibrium of needs between "people" and "planet" in respect of their consumption of natural resources, the consensus is required on:

(a) Who are the primary beneficiaries and what are their unmet needs or desired outcomes;

(b) Who are the primary stakeholders and how they relate to, and complement, each other;

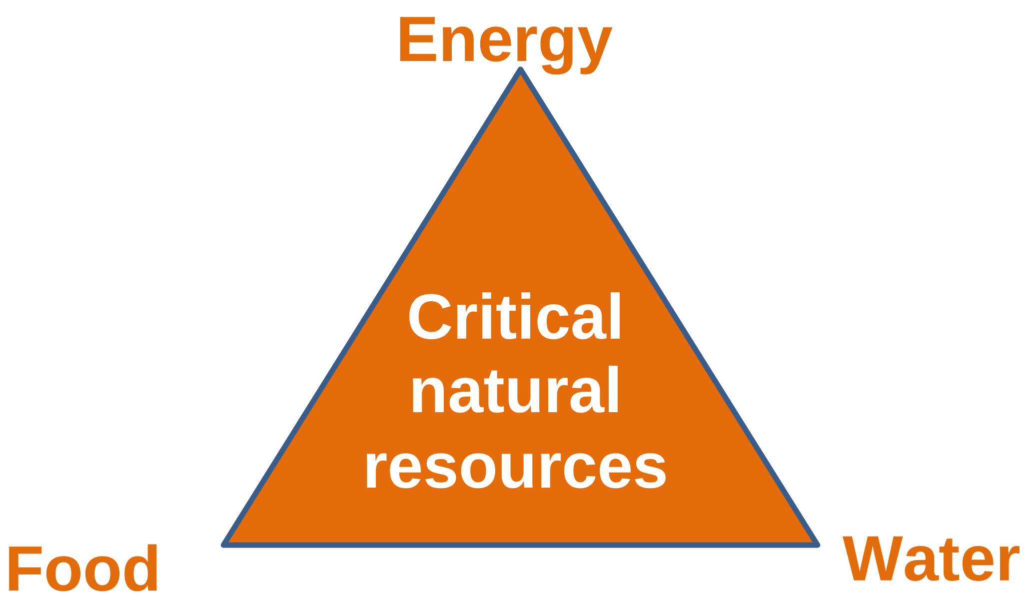
(c) What capabilities and related intangible assets and investment strategies will be required from the stakeholders to meet the needs of the beneficiaries better?

(d) What combination of tangible assets and both new and existing resources and technologies for recovering and managing them will be required for success?

C. Beneficiaries

15. In this document, the primary beneficiaries are assumed to be those people, existing and as yet unborn, whose standard of living and quality of life (ie "prosperity") can be shown to benefit most in value-additional terms from SDG delivery, starting with those with primordial unmet needs of food, energy and water security, affordability and accessibility (Figure 1).

Figure 1
Food, energy and water security as critical natural resources



D. Primary stakeholders

16. The primary stakeholders are assumed to be:

(a) Governments, notably policy-makers and regulators;

(b) Investors, public, private, institutional and retail;

(c) Local communities;

(d) Operators, manufacturers and service providers;

(e) Educators, academia and researchers;

(f) Civil society organizations;

(g) Customers and recipients of services; and

(h) Future generations.

E. Capabilities and intangibles

17. The requisite capabilities are assumed to be in a state of early-stage definition led by a gap analysis designed to pinpoint where existing capabilities are not fit, or not fully fit, for successful delivery of the SDGs. The underlying assumption of how such capabilities are to be developed is that imposing the obligation on stakeholders to deliver the SDGs without the requisite capabilities for doing so is not acceptable, breaching the principle of informed consent. Hence, significant investment in capability enhancement through education, training and professional development – which of course the UN can only recommend, not require - is the *sine qua non* both of operational success and to winning the informed consent of beneficiaries to take part.

F. Tangibles

18. In respect of tangible assets, there is a clear co-dependency for success in:

(a) First, understanding the level of confidence that can be attributed to the preliminary evaluations and classifications of primary resources, and subsequently, before resource recovery begins, knowing in detail and with a high level of confidence, what quantities and qualities of resources are available, where they are located and how best, and in what optimal sequence and combinations, they can be recovered and used, to the equal benefit of people and planet and with the outcome of growing prosperity for all;

(b) Having a clear and compelling narrative to share with beneficiaries and stakeholders as to how the recovery process is to be conducted, under what terms of governance and transparency and with what objectives in respect of distribution of benefits, such that the social licence to operate is negotiated, won and, by continuous dialogue, retained as long as needed;

(c) Ensuring the safety, sustainability and integrity of the system within which the recovery process is conducted such that to the greatest reasonably achievable extent, both primary and secondary resources remain within the boundaries of that system in a "circular" manner that meets the desired end goals of zero harm and zero waste.

19. While there is as yet no normalized model of what a "circular" economy is, it is clear that a pivot is required from a linear model of natural resource management, characterized as "take/make, use, dispose" to a "circular" one characterized as take/make, use, retake/remake". In natural resource management terms, this means shifting from a one-

step “extractive” to a continuous “recovery” modus operandi. In terms of materials flows, this likewise means that nothing unnecessarily or unavoidably leaves the boundaries of the eco-system, i.e. there is “zero waste”.

20. How can UNFC be best adjusted such that its three resource classification axes, E (Socio-Economic Viability), F (Project Feasibility) and G (Geological Knowledge and confidence), become capable of accommodating a zero waste, circular recovery model? A key test of the success of any such modification of UNFC will be its ability to define and classify “new economic resources”. Such resources are generated at the point of convergence between new capabilities (intangibles) and unused or neglected residuals (such as wastes, residues and tailings).

V. Re-centering UNFC – from projects to programmes

21. In terms of UNFC, this refocuses the objectives of natural resource management away from mechanically or chemically based, project specific, extractive processes such as hydro- and pyro-metallurgy towards informatics-based systems for exploring, quantifying and managing natural resources in a smart, integrated manner. This refocus means moving away from single-target “projects” towards programmatic, “eco-system” management techniques applied to combinations of a resource such as found in sedimentary resource basins containing oil, gas, coal, phosphates, uranium, rare earths, water, forest and other resources. This change of approach towards integrated eco-system management programmes depends critically on exploiting inexpensive ever-more powerful processing capability, starting from defining technology gaps and shortcomings and then filling them. This in turn enables:

- The development of new capabilities, whether human, artificially intelligent, or both, *that*
- Trigger innovative business models
  that
- Target TBL outcomes
  in which
- The interests of people, planet and prosperity are aligned.

22. Put another way this pivots natural resource management away from a conventional, natural-resource (oil, gas, minerals, water, soil, etc) centred to a more integrated human-resource centred model, fully in line with the original Brundtland sustainable development model [**Error! Bookmark not defined.**], i.e., designed to meet the needs of both present and future generations.

A. From linear to circular

23. When “resources” per se are re-centered in this manner around human resources, and their capabilities, knowledge and technologies, the production and utilization of natural resources become a “regenerative” activity - in some cases even “circular” - rather than linear and “extractive” as seen and practiced today. This, of course, presupposes, as the SDGs do that generations wish to collaborate forward through time (diachronically) and not just in time (synchronically). If it is agreed that they do, even in the case of generations not yet born, then our resource management methodology has to move away from a project-focused “push” model of resource use premised on “extracting” value” to one that is driven by defining the “pull” of meeting predicated future generational needs. Once these future needs are predicated, the pathway to that future can be charted by working back from them (reverse induction) to our current state. Obviously, such predictive modelling has no

guarantee of success, but it acts as a key modifier for protecting the interests and freedoms of the yet unborn. Hence the transformative vocabulary of the redesigned resource pathway substitutes the term “recovery” for “extraction”, and a single-resource model is substituted by an integrated, eco-system model.

B. The rise of the intangibles – new economic resources

24. With the pivot from natural-resource to human-resource centered management, the change (transformative) drivers pivot from tangibles, e.g., extractive technologies to intangibles. Among these, and in no particular order of significance, are:

(a) A sustainable “decoupled” energy policy framework;

(b) Reworked policies and good practices for local content for all natural resource projects (see the June 2017 Organisation for Economic Co-operation (OECD) position paper [9]);

(c) Development of innovative competencies/ capabilities with enhancing productivity in mind, but also transferability of capabilities from one resource to another to enhance sectoral resilience, based on multidisciplinary project teams, led perhaps by specialist Natural Resource Managers;

(d) Excellent communications:

(i) Inside teams

(ii) Between operators and investors/ financiers

(iii) Between all stakeholders;

(e) Reframing the product offering around the paradigm of raw materials as a service;

(f) Application of smart systems and artificial intelligence to the natural resource cycle;

(g) Adoption of comprehensive resource recovery policies for all resources, with priority given to co- and by-product sources for any mineral, as part of “all-in sustaining cost” financing;

(h) A renegotiated social licence to operate for all recovery programmes based on shared values, a transparent, ethical position regarding risks and benefits and a compelling new narrative;

(i) Delivery of sustainable development goals and zero waste.

C. From push to pull – transformative actions

25. In line with the transformative process from linear to circular natural resource management, a number of system properties change. Among the more significant are:

(a) The system baseline is defined by the safe management of secondary, not primary resources, by which primary resources are conserved and – to the extent reasonably possible - only accessed to top up continuously “remade” secondary resources, hence tending, or achieving “zero waste”;

(b) All natural resources are equally “critical” in nature in respect of the imperative to manage them in an “as efficiently as reasonably possible” a manner, not as a measure of their scarcity or insecurity of supply;

(c) The concepts of food, energy and water security are assumed indivisibly to vest the attribute “security” with the co-attributes “accessibility” and “affordability”;

(d) In the efficient, affordable delivery of resources to meet unmet needs time is of the essence. Hence, the “pull” of unmet need becomes the primary driver (demand side) rather than the “push” of commoditized production (supply side). For the system to be in equilibrium both pull and push stakeholders must benefit;

(e) The application of a "dual discovery" principle to resource exploration and classification, by which is meant using a sequence of actions to discover values, irrespective of whether the target is one or many. First, discovery is made in the ground, which is what a conventional exploration programme does. The current paradigm is that this is the discovery point for a new "resource", which could be eventually converted into a "reserve". Additional value could be discovered subsequently in a second or full discovery phase – such more co-products (e.g. value from wastes), services (eg increased agricultural productivity in the nearby area by providing innovative low-analysis soil amendments from processing residues such as red mud and phosphogypsum etc) during the scoping-, pre- and feasibility study phases. The current thinking of "conversion of resources into reserves" assumes only a small, largely linear selection of a subset of pre-existing materials.

VI. The UNFC toolkit

26. Taking into account the growing impact of intangibles in sustainable resource progression, and bearing in mind the pivot from “push” to “pull” management models, focused on current and predicted future needs, without losing its grounding in classifying the resources in demand, the UNFC toolkit may need to diversify. An outline of what options there may be for extending the UNFC toolkit from its current resource-centred base UNFC was presented in Geneva in preliminary form to the side event “Managing natural resources smartly – a tool to attain the 2030 Sustainable Development Agenda” at the sixty-seventh session of ECE on 26 April 2017; to the IAEA Inter-regional workshop on Uranium recovery from *In-situ* Leach Operations, Beijing, China, 12 October 2017; and, to the Joint ECE, ESM Foundation and EIT Raw Materials Workshop on Strategic Raw Materials and Sustainable Development at the World Resources Forum 2017, Geneva, 24 October 2017, as follows:

(a) **Resource** centred (life-cycle resource management, primary, secondary, circular, zero waste etc.) (current scope of UNFC);

(b) **Customer and service** centred (energy and raw materials as service, the right to produce and sell raw materials and energy and/or form local energy communities, inclusive artisanal resource management);

(c) **Security of supply** centred (maintaining security of supply for food, energy, water, critical material);

(d) **Value and outcome** centred (ending poverty, new economic resources, equitable distribution of benefits, governance, transparency…) (SDG “prosperity” centred).

27. Developing any such extended toolkit will require detailed needs analysis, stakeholder consultation and engagement, and piloting before a robust toolkit, with an associated training and professional development programme can be deployed. The development of this toolkit may require a) the addition of new criteria to the UNFC E, F

and G axes to provide greater range, precision and clarity on attributes of both social and environmental licensing considerations and b) the ability to evaluate additional information than volumes, as for example, specific SDG goal alignment, such as associated CO_2 emissions (SDG 13), various measures of value (SDGs 8 and 9) or reduced waste (SDG 12). In such ways UNFC can assist with SDG compliance through tools which offer clear information and choices concerning the things that matter to each of the stakeholders and beneficiaries.

28. Taking such steps would be consistent with the principle enunciated earlier in this note that we cannot expect to deliver the SDGs without significant and systematic investment in developing the necessary capabilities to do so. Such capabilities include the ability to challenge and change our perceptions of what we mean by resources in the first place. In the circular economy, much that we have been long-accustomed to call "waste" is transformed, or at least transformable, into secondary resources.

VII. Transformative action: secondary resource valorization – example, phosphogypsum

29. A practical example of how a systemic transformation can be conducted is what has happened to phosphogypsum (PG) since 2005. When the so-called "wet" process is used in present-day phosphoric acid manufacture, phosphate rock concentrate is digested with sulphuric acid to release both the phosphate content, known in the industry as P_2O_5, together with very large volumes of PG – some 5 tonnes of PG per tonne of acid. This disruptive variant of the "wet process" was introduced in the late 1920s, when the wet process technology previously used for manufacturing Single Super Phosphate (SSP), which generated no PG, was adapted to create a transformative fertilizer product, triple super phosphate (TSP). TSP was not only a higher grade phosphate fertilizer, but also one which could be combined with nitrogen (typically di-ammonium phosphate (DAP)) for easier and more effective transport and application. The vast tonnage of PG soon became problematic. Some of the material was used in agriculture and construction, but much was either discharged to water bodies such as rivers, lakes and the oceans or disposed of ("stacked") on land. Changes in environmental laws from the 1980s progressively reduced the practice of discharge to water, notably in Europe, while in parallel in the United States of America, until 2000 by far the most significant producer and exporter of phosphate fertilizers, concerns were raised about PG on radiological grounds. PG, like phosphate rock itself, contains Naturally Occurring Radioactive Material – (NORM). In 1989 the United States Environmental Protection Agency (U.S. EPA) promulgated the Phosphogypsum Rule which led the United Sates to a practice of mandatory on-land "stacking". While subsequent reuse or recycling what not expressly prohibited, the conditions for use became so costly and complex that in practice "stacking" became a synonym for permanent disposal. In consequence, some 4 billion tonnes of PG stacks built up on land – much of high value – in more than 50 countries around the world, but principally in the United States itself, in Florida.

30. In 2005, the Florida Industrial and Phosphate Research Institute, now part of Florida Polytechnic University, initiated a systematic, five-year evidence-based review of PG – entitled "Stack Free by 53?"- with a view to removing possible obstacles to market. Working with Nash equilibrium theory [10], based on non-cooperative game modelling [11], the review process developed the so-called "onion-ring" methodology (Figure 2) for mapping the path to market as a set of five progressive decision gates [12]. These consist of:

(a) Technical feasibility;

(b) Regulatory and social acceptability;

(c) Commercial viability;

(d) Political desirability;

(e) Market participation.

31. As shown in Figure 2 and Table 1 these decision gates align partially with UNFC and with the System of Environmental-Economic Accounting (SEEA) [13] but also expose gaps that will need to be filled if UNFC can be re-centered for the circular economy, anchored in secondary rather than primary resource management. They also illustrate how the equilibrium of push (advocacy) and pull (policy and market) factors are critical dependencies in resource progression.

32. At the invitation of IAEA, the team leading the Stack Free project took the lead in developing IAEA Safety Report 78, Radiation Protection and Management of NORM Residues in the Phosphate Industry [14]. Published in 2013, this drew heavily on the Stack Free project evidence-based review to conclude that the radiological objection for use was not supported by the evidence and that PG could be safely and beneficially reclassified as a co-product. Regulators were encouraged by IAEA to find beneficial uses for the material, a call which has since been widely heeded by both regulators and by the industry itself, led from the International Fertilizer Industry Association (IFA). In 2016 IFA published its response to the IAEA Safety Report in the form of a Report to its members – PG Sustainable Management and Use [15] - setting out how a systematic plan for using worldwide PG resource could be approached. Of the annual production of approximately 200 million tonnes use is now running at some 25 per cent from a baseline of near zero per cent. And a valorization pathway is opening up for a wide and sometimes highly innovative range of PG products notably in agriculture and construction, so changing the dynamic of market participation in line with SDG goals, notably SDG 12.5 which requires "By 2030, substantially reduce[d] waste generation through prevention, reduction, recycling and reuse[5]".

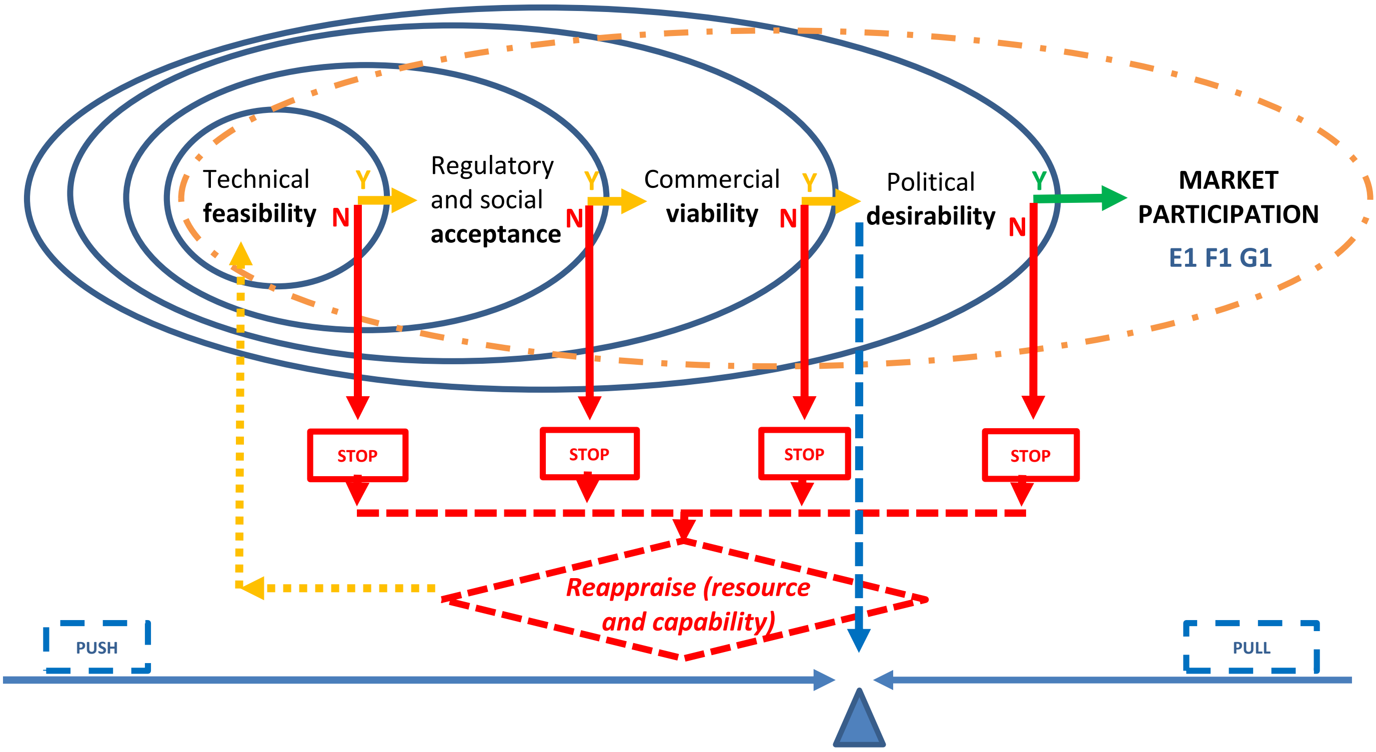
Table 1
Phosphogypsum Pathways – Bridging Table

Step	*Pathway to Market Participation*	*Core documents – anthropogenic resource valorization pathway*	*Commercial evaluation (higher step number = increased market proximity (same as UNFC principle where E1 = market ready)*	*Principles and objectives Public Private Partnership (PPP) projects must observe:*
1	Technical feasibility	Phosphogypsum case study – reporting template	Disruptive or value-add (optimization) potential; RD[3] stage 1, initial laboratory appraisal and single or batch testing; UNFC E3; pre SEEA; decision gate 1	***Improve sustainability*** *and/or comply with SDG goals, e.g. cutting CO_2 emissions to move to a green economy; combat desertification; advance the FEW objectives.*
2	Regulatory and social acceptability	Anthropogenic resources: life-cycle management flow-sheet and related materials flow	RD[5] stage 2, in-depth laboratory appraisal – replicability/ normalization, reliable characterization,	***Engage all stakeholders*** *either directly involved in the PPP project or who might be affected directly or indirectly in the*

[5] For SDG 12.5 see https://sustainabledevelopment.un.org/sdg12

Step	*Pathway to Market Participation*	*Core documents – anthropogenic resource valorization pathway*	*Commercial evaluation (higher step number = increased market proximity (same as UNFC principle where E1 = market ready)*	*Principles and objectives Public Private Partnership (PPP) projects must observe:*
		analysis (planned and actual) compliant with the "graded approach" to risks, notably from radionuclides and heavy metals	compliant with safety limits, continuous testing; UNFC E3; pre SEEA; decision gate 2	*short and/or long run. – the Social Licence to Operate or Informed Consent.*
3	Commercial viability/ capability in place	Project readiness checklist/ with resource progression and capital investment decision-gate flow sheet, including SDG compliant market studies (scoping, pre-feasibility etc.) and business model innovation as needed	Proof of concept – commercial scale: RD[5] stage 3, Pilot project to scalable level (4,000 hours) in advanced or finished state, defined performance standards can be met; UNFC E2 – likely to proceed; meeting SEEA "value release from residual" prima facie requirement, decision gate 3	***Be replicable*** *so that PPP projects can be scaled up and achieve the transformational impact required by the 2030 Agenda. This criterion also needs to take into account whether the local staff and governments have received the necessary training to do similar projects going forward.*
4	Political desirability	Scoping and/or pre-feasibility study – planning and conduct of new commercial-scale project	Validated commercial potential (shovel ready); RD[3] stage 4, engineering and procurement specifications in place, construction contract ready for tender; investment secured, UNFC E2; measurable SEEA value potential (CAPEX (asset) and OPEX (cash flow)), decision gate 4	***Increase access and promote equity****, which means that access to essential services, such as water and sanitation, energy etc. should be increased to people, especially to the socially and economically vulnerable. Furthermore, people-first PPPs should aim to promote social justice and make essential services accessible without restriction on any grounds, e.g. race, creed etc. to all.*
5	Market participation	Benchmark case studies/ commercial scale success stories – replicable projects and good practices	In market (sustainable business) RD[3] stage 5; UNFC E1, customer base/ reliable off-take agreement(s); actual SEEA value release; return on asset (equity growth) and / or return on investment (positive cash flow)	***Improve (demonstrate) project economic effectiveness:*** *projects must be successful, achieve value for money and have a measurable impact by removing a barrier or creating a new mechanism by integrating groups into the global market place.*

Figure 2
The onion ring



33. It was recognized from the outset in 2005 that not only could the fortunes of PG be "transformed" from waste to resource (see Table 1) but that the method could apply to other large volume residuals such as tailings and residues from many other resource industries, many of which also have radiological issues in the form of NORM or other risks of toxicity and harm which can be managed with selection of appropriate use strategies. This aspect will be tested as one of the current modification processes to UNFC, the draft specification for application of UNFC to anthropogenic resources is reviewed and tested in parallel with the review of this note.

34. It was also recognized, notably in Central Florida where the Interstate 4 is one of the five fastest growing and most productive economic zones in the United States, that the sheer quantity of land taken up by PG stacks, much of high value such as along Tampa Bay, was increasingly stressing decisions over land use that became necessary as the population of Central Florida rapidly grew. Such land use pressures caused by encroachment on PG stacks are equally apparent in many producing countries, including Brazil, China, Greece, India, and Spain.

VIII. The digital revolution

35. Of the primary transformational agents for future, sustainable natural resource management one is intangible, the other tangible. The intangible is the policy – vision perhaps – of zero waste and valorization of secondary resources. The tangible is the digital revolution, also known as Industrialization 4.0. More powerful, smarter, artificially intelligent processing power is necessary to create a viable and prosperous 4.0 industrial

eco-system based on integrated resource management and value-additive materials flows. But only by adopting the voluntary constraint of zero waste will the systemic change required to achieve the SDGs change the culture of resource management to a sufficient degree to transform it.

36. While hitherto technology limitations were seen as constituting an insurmountable barrier to transforming the natural resource management culture, the digital revolution - underpinned for many years by Moore's law, by which processing power continues to double every 18-24 months while simultaneously halving in price - makes breaching this barrier a distinct possibility. Perhaps processing technology has already advanced to a point where the next quantum leap in computing technology may shift the burden from human vision with computer-assisted management to human/AI vision with computer management. That is, efficiencies that are unattainable in human terms alone will make full secondary resource valorisation and zero waste viable goals.Some of the many consequences of the barrier coming down – summarized as the pivot from "push" to "pull" - are set out in Table 2.

37. It is, however, already clear that this revolution has risks and costs associated with it not just potential benefits. Some mining and processing companies report that they have invested heavily in new "smart" systems only to find that operators have the habit of either over-riding or misinterpreting the data generated by these systems with the result that accuracy and productivity reduce rather than increase, with consequent negative impact on operating margins. In commoditized industries where margins are already under significant pressure, the results in respect of financial outcomes can be very costly. Perhaps artificial intelligence techniques can be used to "design in" or embed forms of intelligence into such operating systems that user over-rides can be quickly detected and evaluated. Perhaps the role of the operator as hitherto understood will completely change?

Table 2
Energy and mineral resources as example of SDG delivery by "Pull"

Push	*Pull*	*Drivers*
Energy and minerals resources as commodity	Energy and minerals as service	New business models
Energy and mineral resources for sustainable development-	Clean energy and minerals (such as REE and Li) in keeping the 2˚C secondary target on track.	Transformative technologies, AI
Extract it, and they'll trade it	Minerals in ground, available on demand	UNFC-based new resource management
Single target resource/ Single purpose	Integrated resource management (comprehensive resource recovery)/ Integrated purpose: e.g. whole [energetic] basin	New economic resources Zero waste Integrated flowsheets
Technology selection output driven	Technology selection, including digital/ AI, outcomes-driven	Constructive regulation Transformative technologies, AI
Negative externalities and safety managed by "defence in depth" (tailing dams etc.)	Reuse and recycling Only positive outcomes, safety in design	Waste hierarchy transformative technologies, AI

Push	*Pull*	*Drivers*
Fixed marginal cost of producing additional units	Nudge economics Zero marginal cost of production	Transformative technologies, recombination of technologies, AI
“Rival” goods and commodities	“Non-rival” services	Transformative technologies, recombination of technologies, AI
Operate through fixed value-chains (provider-customer relationships)	Operate through flexible platforms (providers and customers are interchangeable)	New platforms, AI
Productivity stagnation	Productivity growth	AI
Projects tangibles driven	Programmes, intangibles-driven – capabilities, values, communications, ethics	UNFC based new resource management
Risk assessment in isolation	Risk/risk assessment (risk of doing vs risk of not-doing)	Constructive regulation
Extensive - high footprint land/ marine use	Intensive – High-intensity low footprint land use	Land use priorities New technologies
Waste inevitable/negative externality (waste ejected outside system boundary)	Secondary resources (waste retained inside system boundary)	Zero waste New technologies, AI
Specialized skilled and unskilled jobs	Productivity enhanced jobs/ diminish routine and repetitive tasks	New industry curriculum
Linear economy - Make-use-dispose	Circular economy: Make - use - remake	New technologies, AI
Market – win/lose	Nash-Stackelberg equilibrium win/win	Cooperative game strategy
Primary resources main system driver	Cluster of resources main system driver	New Business Models

IX. Consequences for UNFC – innovation from push to pull

38. In terms of UNFC, the transformation from linear “push” to circular (continuous recovery) pull refocuses attention for meeting sustainable development goals away from the E axis towards a restricted F axis, one focused on identifying and characterizing technology gaps and shortcomings, viewing these as surmountable challenges, or unmet needs, rather than limitations, and innovating affordable techniques and technologies for doing so.

39. In this, resilience and innovation (SDG 9) are key. Innovation means sometimes doing better, sometimes doing different, sometimes resetting completely the point of equilibrium from which the properties of the system as a whole derive. Whichever strategy is followed, enhanced resilience results as a value-add. The E axis, therefore, needs to refocus on encouraging resource progression through innovative business models that can discover a “cluster of values” simultaneously applicable across a range of SDGs, so building prosperity in an “eco-system service” model. This will drive resource management

in a different direction altogether from the current "commodity" model. The benefit for UNFC, in general, is that it can operate as a tool for dual, or even continuous, discoveries across the whole resource life-cycle. For example, the initial discovery of energy or material in place (G axis aspects) may lead to a subsequent discovery and /or design of a set of values in its production and utilization pathways (E axis and F axis aspects). A combination of AI and human tools may, for example, be able to evaluate all available materials in an economical transport radius against societal needs and production technologies.

X. Risks and challenges

40. Making the change from push to pull brings with it many risks, of which one, in particular, is perhaps the most severe for successful (prosperous) natural resource management. This is the risk of an asymptotic gap opening up between what is in principle possible for modern 4G resource recovery to accomplish and what is done. That such gaps can open up quickly and with highly damaging consequences by arbitrarily restricting social and economic growth for reasons of vested interest, is not as such a new phenomenon. It was, for example, a major preoccupation of the Enlightenment and a hotly contested issue at the time between the French Encyclopaedists and the English Royal Society as to how technical and scientific innovation can best be deployed in economic development in a way that creates rather than destroys wealth. In contemporary natural resource management, the dilemma can best be illustrated by the profound asymmetry between "project" and "processing power" life cycles. In natural resource project terms, the time it takes from discovering a new resource to successfully recovering it on a commercial scale is now commonly 25 years or more, i.e. it takes a whole generation to transition from discovery to recovery. In terms of processing power and wider processing capability, according to Moore's law between 10 and 15 technology life-cycles will have elapsed in the same period. What has happened as a result is that resource recovery and resource management time-lines have started to diverge at an alarming rate and the gap between what could be done and what is done is at risk of the asymptote.

41. Perhaps artificial intelligence (AI) can function as the adaptive bridge that crosses this asymptotic chasm? If so, it has to enable reverse engineering from transformative outcomes predicated to be reached at increasingly distant future time points. If this can be done, it will enable the development of increasingly powerful exploration and discovery tool that can be applied to specifying programmes for sustainable and integrated resource management. These can be used to complement, or even modify, existing tools for increasing productivity and enhanced return on investment (ROI) from recovering existing resources. The objective would be to create new economic resources from integrated natural resource recovery in ways we never thought of as possible before, stimulating innovation in breakthrough technologies to achieve such outcomes. Such ambitious approaches have disruptive attributes perhaps but are best characterized as disruptive because they do not displace anything that currently exists with something new.

42. The consequences for the operation of both F and G axes within UNFC could hardly be more profound. In regard to the F axis, levels of recovery, accuracy and efficiency are now achievable that even ten years ago would have been impossible, such that significantly lower avoidable losses and leakages from in-ground to end use and reuse can be confidently predicted. The capital intensity of many of the current industry-standard technologies in use may delay the introduction of such tools and techniques for socio-political reasons. In terms of the G axis, the very concepts of how a "resource" is defined and then how it becomes a "reserve" are being redefined as traditional key metrics such as cut-off grades of even internal rates of return become increasingly arbitrary or volatile.

43. The impact of the digital revolution is so profound that it has become imperative, within the framework of constructive regulation, to find a sustainable way to redesign the resource recovery pathway and tool-kit to bring it into synchrony with the 4G resource management system. UNFC operates already within the constructive regulation space because it rests on a voluntary alignment of interests between government, regulators, operators, finance and academia – i.e., it illustrates well SDG 17. It must, however, articulate this objective in an explicit manner rather than leave it “felt” but unsaid.

XI. System of Environmental-Economic Accounting

44. Encouragingly, other UN tools which can be applied to SDG delivery, and which align well with the current direction of travel of UNFC are already a little further down the transformational path. The intangible, transgenerational benefit of increased prosperity, which flows from aligning the interests of people and planet sustainably, is anticipated in the UN supported System of Environmental-Economic Accounting (SEEA) [13]. SEEA, which emanates from the World Bank, the IMF and the OECD, and which is still very much in its infancy, is of course fundamentally concerned with economic development - prosperity. While it predates the adoption of the SDGs, it explicitly shares a common lineage with them from the original 1987 Brundtland statement of the nature and goals of Sustainable Development in Our Common Future [3] and is designed to promote sustainability and wealth creation. In that sense, its founding assumptions are fully consistent with the SDGs and its particular emphasis on “value release from residuals” aligns perfectly with the rapidly emerging adoption of “zero waste” policies in natural resource management of all kinds.

45. Like the way the 2030 Agenda for Sustainable Development is framed in a linguistically and conceptually transformative manner, not the least of the remarkable attributes of SEEA is (a) its hyphenation of two of the TBL adjectives, and (b) the order in which it hyphenates them, “environmental-economic”. This simple act of coupling creates a new, Nash-like point of equilibrium in the integration of environmental and economic measures of return, which sets the syllogistic first principle from which any future version of UNFC can be derived, drawn and applied. This syllogism thus works as follows:

(a) All sustainable natural resource management and progression activities keep the interests of people and planet in equilibrium in meeting their needs;

(b) UNFC is a tool for classifying and measuring the nature and progression of natural resource management;

(c) Therefore UNFC is a tool that keeps the interests of people and planet in equilibrium, delivering prosperity through efficient, transparent and equitable resource progression and use.

XII. Lineage from Brundtland, Our Common Future

46. The 2030 Agenda has its roots firmly set in the 1987 Brundtland-defined objective of aligning the interests of all inhabitants of the planet through the recognition that we all share a “common future”, but it aspires to something more. Brundtland locates the source of the energy that drives sustainable development in the dialectic of two key, but asymmetrical, concepts, as follows:

(a) The concept of 'needs,' in particular the essential needs of the world's poor, to which overriding priority should be given; and

(b) The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

47. The first of these concepts rest on the absolute moral imperative that no one must be left behind – an imperative also embedded in the 2030 SDGs – but modifies this absolute with a second concept (an "idea") which in practice is a relativistic qualifier, that any generation only has capabilities to meet this goal that its combination of technology and social organization enables it to develop and mobilise. Hence sustainable development in that model is necessarily in disequilibrium between aspiration and delivery.

48. The 2030 Agenda, especially when viewed through the lens of the SEEA, is premised on equilibrium, and as such may be seen as a balanced development model for all natural resources. It does not disavow in any way meeting the "essential needs of the world's poor" foregrounded by Brundtland in 1987 – SDG 1, after all, is "Ending Poverty" – but it challenges the wording of the second Brundtland concept, that limitations, whether of technology or social organization, are "imposed" on the environment and hence on its ability to meet future needs. It does so most obviously in SDG 9 "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation". In such a model, while constraints inevitably remain on or in the eco-system, these are not "imposed" but simply mark inevitable but permeable and dynamic boundaries between the "possible today", the "possible tomorrow" and the "possible day-after-tomorrow", ie the naturally developing stages of the growth of the eco-system.

XIII. Transforming our world through investment

49. Not by accident, SDG 9 is the point of departure of the landmark 2016 publication, "Transforming Our World through Investment" [16]. Perhaps counter-intuitively the supposedly risk-averse world of institutional investment in this publication, the work of Share Action, the "movement for responsible investment" presents itself as both wholly in favour of aligning its investment strategy as a whole with delivering the SDGs through investment and ranking the need to meet SGD 9 as in first place in its alignment procedure. Responsible for USD$5.9 trillion, approximately one-sixth of the total pension fund investments of the world, this group, with members in thirteen countries, has analysed in detailed how to classify and rank the SDGs such that prosperity is the outcome for people and planet.

50. In the context of aligning their future investment strategy as a whole to delivering the SDGs the fund managers rank SDG 9 in first place as an investment driver – "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" – SDG 13 in second place - "Take urgent action to tackle climate change and its impacts" - and SDG7 in third place - Ensure access to affordable, reliable, sustainable and modern energy for all". In that model the future management of all natural resources will be decided by i) innovation, ii) their contribution to climate action and iii) their direct or indirect role as an energy source. Further, as an example of how previously neglected "wastes" such as PG can be transformed into valuable secondary resources as part of a conscious investment strategy, 57 per cent of the fund managers rank SDG 15 in fourth place in respect of priorities for investment action, namely measures to combat desertification and halt or reverse land degradation.

XIV. Working Group on Sustainable Development Goals delivery

51. In keeping with the establishment of that new point of equilibrium, the Terms of Reference (ToR) for the Sustainable Development Goals Delivery Working Group,

established 28 April 2017 at the eighth session of the Expert Group on Resource Classification are likewise based on the premise that prosperity is the key performance indicator against which progress on delivering the SDGs for the betterment of people and planet can be measured. If such measurement can be conducted successfully, the chances of progress in delivering the SDGs are naturally enhanced, in line with ToR 3: "To demonstrate through good practices and case studies that SDG compliant businesses augment or create wealth and prosperity rather than deplete or destroy it".

XV. Zero conditions for sustainable management of natural resources?

52. A significant range of consultation meetings and workshops was held in 2017, prior to the drafting of this note. This process in turn built on a sequence of inter-regional meetings, study visits and workshops conducted in cooperation between international organizations such as ECE, IAEA, the Ibero-American Program of Science and Technology for Development (CYTED) and held locally in association with national institutions, professional associations and private sector companies. These include the European Federation of Geologists (EFG), the African Minerals Development Centre (AMDC) and the World Resources Forum.

53. From these activities, four "zero-conditions" for sustainable natural resource management (Figure 3) have crystalized. These are:

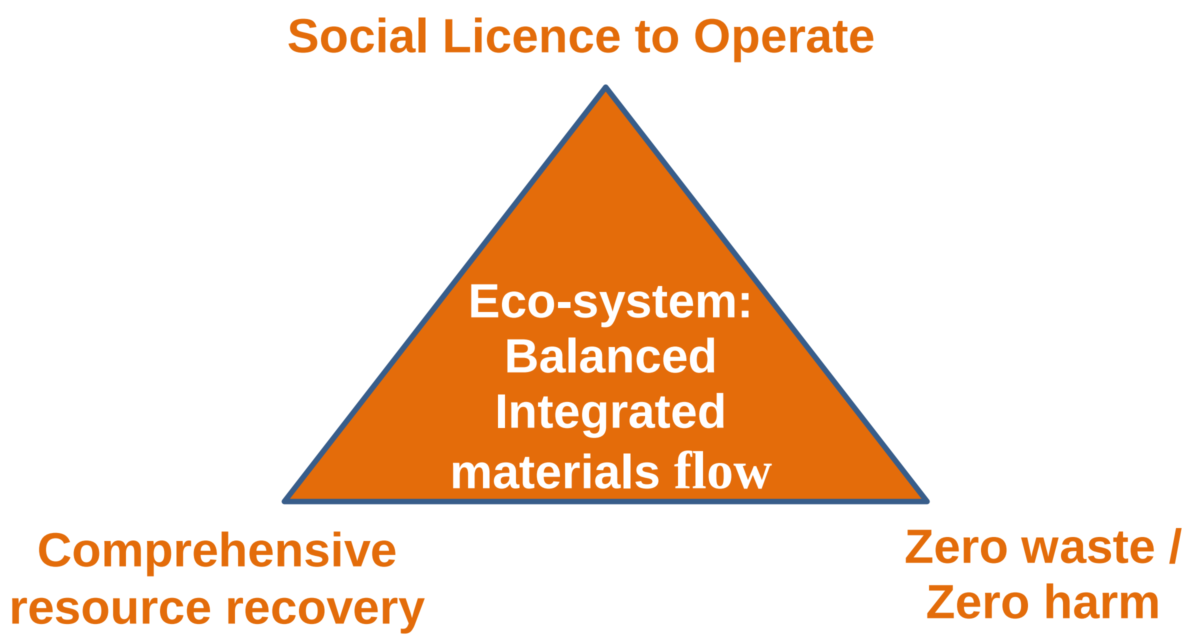
(a) Zero Waste (0W)/ Zero Harm (0H);

(b) Social Licence to Operate (SLO);

(c) Comprehensive Resource Recovery (CR) [17]; and

(d) Integrated materials flow within a 4.0 eco-system.

Figure 3
Four zero conditions for a sustainable natural resource management eco-system



54. As SEEA expresses it, the primordial characteristic of the eco-system is balanced; integrated materials flow: “Physical [materials] flow accounts”, explain in detail the recording of physical flows. The different physical flows—natural inputs, products and residuals—are placed within the structure of physical supply and use [eco-system]; and from this starting point measurement of the [materials] flows can be expanded and reduced to enable focusing on a range of different materials or specific flows” [13].

XVI. Building new narratives and aiding better decision-making

55. Neoclassical economics has shaped our understanding of human behaviour for several decades. While still an important starting point for economic studies, neoclassical frameworks have imposed strong assumptions, for example regarding utility maximization, information, and foresight, while treating consumer preferences as given or external to the framework [18, 19]. Behavioural insights can help policy makers obtain a deeper understanding of the behavioural (demand and supply-side) mechanisms contributing to energy and raw material issues, and design and implement more effective policy interventions [20]. While most of the focus to date has been on the demand-side, such as conservation and recycling, the whole life-cycle from supply side included, should be considered in an integrated manner. Efficiency improvement, waste minimization etc. involves all critical points along the value chain.

56. Succinct narratives could also be developed to improve policy and decision-making avoiding many of these biases. For example, energy and raw material industries have traditionally used terms such as “extraction” and “exploitation” without understanding their impact on the human behavioural responses. Behavioural (“nudge”) [21] and neuro-economics today provide a basis for understanding how human brains construct narratives from existing information, which is usually coloured by many heuristic biases.

57. The failure to build a common narrative of what the objectives are of equitable natural resource management has put many resource projects at high risk, with both social and economic negative consequences. This narrative failure may not be obvious when social contracts are first negotiated, largely due to the inexperience of one or even both parties. The result is that key reference points, such as clarity concerning stakeholder expectations, are commonly neglected; or there may be no social and environmental baseline data to work from, sowing the seeds of future failure and very expensive write-downs. Grounding stakeholder engagement in a sound understanding of behavioural economics will increase the chances of a common narrative being created and sustained from a very early stage, enabling a realistic, well-accepted energy and raw material policy, making as well as space for generating innovative business models.

XVII. Mapping the new SDG-driven system boundaries

58. Applying these four zero conditions, the Working Group has started to consider what techniques can be developed to map the boundaries of the new SDG-driven natural resource management system. Once the mapping is further advanced, it will become clearer what the UNFC toolkit might need to contain, but some options were already presented and reviewed during the special session of the Expert Group held to coincide with the sixty-seventh session of ECE, Geneva, 26 April 2017.

59. Some of the principles of the system are articulated above (Figure 3). An application of those principles will be complemented by further case studies, such as of PG, and by a small selection of “thought experiments” such as how to build a resource recovery system for an entire sedimentary basin. The ‘Stack Free by 53’ project alluded to acts as a

reference point for this method because it began, as its title suggests, as such a thought experiment.

A. Method

60. In seeking to map the system boundaries some of the high-level approaches will address:

(a) "Vertical" issues:

(i) mining including tailings

(ii) residues/ legacy co-products

(iii) conflicted land uses

(iv) water resources

(v) energy resources etc.

(b) "Horizontal" issues a) competences, expertise and experience, b) policies, with the intention to enhance governance, transparency, treaty or SDG compliance

(c) Possible "eco-system"-wide solutions /zero waste convergences

(i) by integrated, sequential resource management (the "whole basin comprehensive recovery" approach) or at least

(ii) by targeted co-locations and combinations, such as phosphogypsum and red mud.

61. Consistent with re-centering on secondary sources the conventional model of “greenfield” projects preceding “brownfield” will be reversed for:

(a) Brownfield, unlocking value and resource release from a highly costly, possibly abandoned legacy site; and

(b) Greenfield, an innovative way to design and execute a new project that avoids the pitfalls and traps of the brownfield models.

B. Case Studies

62. Case studies will (provisionally and subject to modification) be approached as follows:

B.1 Purpose

63. Analyze existing multi-factorial resource management projects whose attributes address multiple SDGs and in so doing reveal the likely boundaries of the transformed “integrated” system or which will require transformative methods and technologies to resolve

B.2 Worked examples

64. Worked examples identified for further analysis include:

- Coal mine methane (India) - "comprehensive recovery" of methane as a co-located resource. Link to ECE Group of Experts on Coal Mine Methane.

- Artisanal mining (Tanzania) - a structured and intentional adjunct to commercial scale v high value/low utility products - e.g., gold and diamonds in Tanzania versus totally unsupervised and ad hoc.
- Phosphates and its co-products (general) – phosphogypsum, uranium and rare earth elements. Link to the UNFC Anthropogenic Resources Working Group and MINEA project.
- Remediating degraded and desertified soils, with anthrosols "designer soils" from various residues, e.g. red mud, copper slag, phosphogypsum, dredged materials. Annual fertile soil loss now estimated at 16 billion tonnes (UN Environment).
- Marine environment oil and gas rig/infrastructure decommissioning (North Sea).
- Reopening closed mines (e.g. Portugal (copper-gold), Spain (uranium), Cornwall, United Kingdom (lithium brine)) – resource future-proofing.
- Zero Waste (China) – zero waste policy being applied to management of uranium tailings using digital mining techniques.
- Digital quarrying (Republic of Korea) – increased accuracy and productivity, waste volume reduction.

C. Thought experiments

65. Several advanced concepts could be envisaged, which could focused upon on a longer time frame:

- Energetic basin resource mapping and recovery.
- Digital (artificially intelligent) mining for zero waste planning and delivery.
- Neologisms for SDG delivery.

XVIII. Working Group Work Plan delivery: curriculum, policy, eco-system

66. As presented and discussed at and around the World Resource Forum Workshop, Geneva, 24 October 2017, the SDG Working Group work plan in its first iteration will comprise three main components:

(a) Curriculum (human needs and capabilities, technologies);

(b) Policy;

(c) Eco-system.

67. Each will address a specific task or objective, from which the pathway to the integrated industrial eco-system can be better understood and hence more effectively delivered.

(a) Develop the curriculum to apply revised UNFC to the competent, responsible management (integrated-indivisible-balanced) of natural resources;

(b) Shape the resource management policy objectives to meeting the key outcomes (zero harm, zero waste, comprehensive recovery, social licence to operate);

(c) Develop and deploy the requisite innovative - capabilities, technologies, integrated materials flows - to deliver the industrial eco-system.

68. The discrete steps which emerge from the analytical process will then be mapped back to UNFC, with a recommendation for modifications to UNFC as needed.

XIX. Funding

69. If the response to this document remains as favourable to the three point Working Group Delivery Plan as was the initial response from decision and policymakers to whom it was presented and with whom it was discussed at the World Resource Forum, Geneva, 24 October 2017, then it may be expected that there will be a degree of consensus as to how what will be a highly ambitious undertaking – enhancing the UNFC tool-kit to serve better the twin tasks of delivering the natural resource management part of Agenda 2030 and the Paris Agreement on climate action can be resourced and funded. This response was particularly significant for "next generation UNFC" as it came from experienced participants in natural resource planning who had no previous exposure to UNFC and who were, for the most part, unaware of its existence.

70. The issue was debated at the World Resources Forum Workshop as to "if", and if so, "how", to submit UNFC to a "step change" (or "game-changing") review to imbue it with the capability as a tool-kit to contribute to Agenda 2030 and the Paris Agreement.

(a) What are the "Requisite technologies and raw materials" to meet the core needs of the Sustainable Development Goals"?

(b) How does UNFC as a tool for natural resource progression need to be revised and restructured to advance delivery of the SDGs by managing those technologies and raw materials efficiently to meet those core needs?

71. In respect of "if" the consensus was clear and non-negotiable: if UNFC does not submit itself to such a review its capacity to contribute to Agenda 2030 will be severely constrained. In regard to "how", the consensus was that John Nash was right: to get to a "win/win/win" answer much thought is required, much consultation, much analysis, much testing, much bargaining.

72. The delivery planning process itself – the how - will require skilled and experienced leadership, a significant investment in stakeholder consultation and engagement, and a transparent drafting and review process. And once the set of activities is defined of which the "next generation UNFC" delivery plan will consist, success in implementation (the bargaining) will depend heavily on a well-resourced, iterative sequence of pilot-testing tasks and events, complemented by a high capacity to capture feedback, to adapt and to innovate, such that the compelling case for its widespread use is clearly and persuasively made - win/win/win. The delivery effort will necessarily be coordinated from ECE in Geneva, an effort that will require commensurate extrabudgetary staff and financial support.

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