Revision Notes

Reply to the reviewers for hess-2020-197

Title: A Water-Energy-Food Nexus Approach for Conducting Trade-off Analysis: Morocco's Phosphate Industry in the Khouribga Region

Authors: Sang-Hyun Lee, Amjad T. Assi, Bassel T. Daher, Fatima E. Mengoub, Rabi H. Mohtar

Dear Editor and Reviewers

Thank you for considering the manuscript for publication in the **Hydrology and Earth System Sciences (HESS)** and in-depth review of the manuscript. In this study, we developed the WEF-P tool which is a decision support system for linking phosphate industry to agriculture in terms of water-energy nexus perspective. In particular, we adapted the supply chain analysis to quantify the water and energy footprints and assessed the impacts of water allocation between industry and agriculture through dynamic production of phosphate using the WEF-P Tool.

The main comments from reviewers were related to 1) lack of literature reviews, 2) strength of this tool in comparison to others, and 3) economic and environmental impacts assessment. Therefore, in the revised manuscript, we revised the introduction with more literature reviews and reorganized the structure of our manuscript in order to improve its readability and highlight the novelty of the present work. In particular, we have detailed explanation about methodology of the tool, data survey, scenarios, and footprints modeling. In addition, we compared this WEF-P Tool with WEF Nexus 2.0, and added the limitation of economic and environmental impacts assessment through the WEF-P Tool.

Main revisions

- Revising introduction with more literature reviews
- Reconstructing and revising the materials and methods section
- Adding limitations of economic and environmental impacts assessment

In the revision notes, you will find a point-by-point reply to specific comments.

We appreciate again your thoughtful comments and look forward to hearing your reply.

Kind regards, on behalf of all co-authors,

Sang-Hyun Lee

Revision Notes

Major Comments (Reviewer #2)

Comments 1

Reviewer's comments	1- The author didn't give a clear idea about the water footprint and energy footprint and how they contribute in the assessment scenarios, did they matter when it comes to producing a clean food? And concerning the Carbone footprint, is the Carbone show a real danger in front of all the radioactive components of phosphate?
Response	Footprint indicates the amount of water or energy consumed per final products, which have various sub-processes in supply chain. Each process has a distinct footprint, identified as a regression function or average value from the technical (engineering) perspective. Based on the survey data, average electricity footprint (kWh/ton) can be estimated. The WEF-P Tool estimated the average value of the footprint and the function of the relationship between water-energy consumption and phosphate production using the historical data (in this study, year 2015). Technical experts in each process can modify the relation function once needed. To calculate CO2 footprint, we need to consider various factors and complex relationship. In particular, CO2 emission has not been measured in mining area, and CO2 emission from crop area is another level of research. Therefore, in this study, we limited CO2 emitted by fuel energy use (direct emission) and electricity generation (indirect emission) and applied the reference CO2 footprint.
Revision (Line 227-237)	The main function of the WEF-P Tool is identification of the relationship between resources and production, and the quantification of the resources consumed in phosphate production. The methodology is based on life cycle assessment. The water and energy footprints were analysed, indicating the quantity of water or energy consumed in various sub-processes in the supply chain's integration of production and transportation. The technical details of each process are specific and aggregated into functional processes. The main component is the footprint, which indicates the water and energy requirements for phosphate products, and the CO_2 emitted through energy consumption. Each process has a specific footprint based on field data and fed into the tool monthly, or when a significant change in capacity of the functional processes has occurred. For all footprint processes in Khouribga, the amount of raw phosphate is measured in commercial metric tons embedded in slurries and rock. Even if the phosphate rock changes to slurry through several processes, the amount of raw phosphate embedded in products is not changed. Thus, the tons of phosphate in water and energy footprints indicate the raw phosphate embedded in the products in each process and is constant through entire supply chains.
Revision (Line 263-267)	Although real emission in each process in supply chain should be measured, this study is limited measuring CO_2 emission in mining area. In addition, CO_2 emission in crop area is related to soil and crops, and it is another level of research. Thus, we limited CO_2 emission to that emitted by fuel energy use by machinery (direct emission) and electricity generation in power plants (indirect emission), and the reference CO_2 footprints were applied (Table 2).

Table 2 CO_2 emission by burning fuels and generating electricity

CO_2 emission by burning fuel		CO_2 emission by generating electricity			
Sources	CO_2 emission[1] (kg of CO_2 L^{-1})	Sources	CO_2 emission by sources[1] (ton of CO_2 10^{-6} kWh)	Proportion of sources in Morocco[2] (%)	CO_2 emission (ton of CO_2 10^{-6} kWh)
Gasoline	2.59	Coal	1,026	43.4%	
Diesel	2.96	Petroleum	1,026	25.3%	
		Natural gas	504	22.7%	820.9
		Hydroelectricity	19.7	6.9%	
		Renewables	15.8	1.7%	

[1] U.S. Energy Information Administration (https://www.eia.gov)
[2] International Energy Agency, 2014.

Revision Notes

Comments 2

Reviewer's comments	2- The author applied the tool considering the phosphate as a simple nexus component like water or energy. Otherwise, there is a need to emphasize all environmental and economic aspects related to this product and the interaction between agricultural and phosphate production in the study area, to consider that this tool is efficient and can be considered as the best decision-making tool when it comes to this type of nexus.
Response	Some of phosphates are exported but a lot of them are transported to Jorf Lasfar and used as raw materials for phosphorous fertilizers. Thus, the economic value of phosphate could be changed by the types of fertilizers, and it is actually difficult to apply the static economic value to the model. In addition, still there are a lot of discussion about water value are ongoing. Thus, we added more explanation why we did not mention the economic perspective in this study.
Revision (Line 180-194)	However, the WEF-P Tool has limitations in assessing economic impacts such as cost and benefit analysis. This is because cost must include the price of water, which is sti ll under discussion, and the price of products when analysing their benefits. Raw phos phate is transported to the manufacturing area and used in the production of various f ertilizers that have different prices: this makes it difficult to set the price of excavatin g raw phosphate in the mining area. Sustainability assessment also has qualitative asp ects in terms of environmental impact. The WEF Nexus Tool 2.0 applied the sustaina bility index based on resource capacity and availability, however, it is still a quantitati ve aspect. We should consider the meaning and definition of sustainability, both quant itatively and qualitatively, and then assess the index using the stakeholders' weights f or the variables related to sustainability. Additionally, spatial and temporal scales shou ld be included in a sustainability index. For example, the pipeline transportation syste m requires water, which is transported with products: the pipeline causes greater water use at the origin, but also provides additional water to the destination area. Also, the water requirement differs with temporal season, such as the water intensive agricultura l production season. Thus, more research is needed for a sustainability assessment bas ed on economic and environmental impact. However, the quantitative analysis is an es sential factor for assessing sustainability, therefore, the WEF-P Tool focuses on quanti fication of 1) water and requirements for phosphate production and transportation, 2) carbon emissions by energy used in product processes, 3) water supply system and tra nsportation, and 4) dynamic production impacts on water and energy savings.

Comments 3

Reviewer's comments	3- The paper is not well structured, there is a gap between different sections in the paper. The author didn't explain the choice of the scenarios and the methodology of data collection.
Response	We revised the methodology part with more details of site description and framework of WEF-P tool. First, we added more explanation of site, units, and footprints analysis in 2 Materials and methods. In addition, we added the comparison between WEF Nexus Tool 2.0 and WEF-P Tool in order to explain the details of framework of the tool. In addition, we re-constructed the methodology section with more details of site description and overall framework of WEF-P Tool. In 3 Results and discussion, we made "3.1 Application of scenarios" to define the scenarios before representing the simulation results.

Revision Notes

Comments 4

Reviewer's comments	4- In the discussion part, no scientific comparison, even if the tool developed by the author, it is important to compare the findings, especially in the WEF nexus impact on water and energy footprint and CO2 emission.
Response	We agreed with your comment. The main purpose of this study is to develop the tool and apply it to link the industry and agriculture in the context of regional water-energy boundary. However, we assumed some scenarios about agricultural production and also focused on quantitative assessment such as water and energy requirement. Thus, it is limited to assess the economic and environmental impacts through the current tool. However, this tool is able to be improved with more case data and field survey, thus this tool is useful as the platform adapting the scientific research and policy of industry and agriculture. We added some founding and contribution of this study briefly in Conclusions section. Please understand these limitations.
Revision (Line 459-468)	In other words, the WEF-P Tool offers a decision support system to provide quantifiable trade-off analyses for management decisions such as increasing production, transportation systems, and water allocation. The developed WEF-P Tool enables users to: • understand and identify the associated footprints of the primary functional production processes and existing flows in production lines; • identify the main sources of data to be gathered and fed into the model on a specific temporal basis; • identify the techniques employed to conserve or produce water and energy and minimize the impacts of phosphate production; • form a translational platform between sectors and stakeholders to evaluate proposed scenarios and their associated resource requirements
Revision (Line 489-495)	Beyond the limitations, the deliverables from this study include a conceptual and analytical model of the phosphate supply chain in Morocco, the WEF-P Tool. The Tool can assess the various scenarios to offer an effective means of ensuring the sustainable management of limited resources to both agricultural area and phosphate industry. It quantifies the products (phosphate) and resource footprints (water, energy) across the supply chain; identifies the interlinkages between water and energy in phosphate production and transport, and establishes reference values for comparison of outcomes and performance. The WEF-P Tool enables the user to evaluate trade-offs between water resource allocations and the impact of the Moroccan phosphate industry with agricultural water use.

Revision Notes

Specific Comments

Comments 1

Reviewer's comments	1- The introduction is too general and missing a good literature review. The author didn't talk about the novelty of the use of the WEF-P tool and the difference between it and the WEF tool (http://www.wefnexustool.org). There is also a need to emphasize the pros and cons of the used tool, especially that phosphate production has a very interesting economic value but a very bad environmental impact, and here comes the importance of the concept of the sustainability index existing in the WEF tool 2.0.
Response	We appreciated your comments. In revision, we tried to represent why this study is important and what is the difference from previous research through more literature reviews in Introduction section. However, as we mentioned in Major comment, there are limitations of economic and environmental impacts assessment through this tool. We explained these limitations in revision.
Revision (Line 71-83)	The nexus framework is dependent on the stakeholders, scales of boundary, and analytical tools. In considering the application of the nexus as a platform, an integrated modelling approach is essential. These issues manifest in very different ways across each sector, but their impacts are often closely related in terms of trade-offs. In particular, the sub-nexus needs to be effectively conceptualized and a theoretical sub-nexus developed. Private-sector water, energy, and food supply chain players are the key stakeholders to address current contradictions that arising as a consequence of attempts to develop a grand nexus approach (Allan et al., 2015). Accordingly, we must consider the "specialized" nexus of multi-stakeholders, such as agriculture, industry and urban areas, for which water, energy and food are treated as subsystems. Current nexus frameworks often focus on macro-level drivers of resource consumption patterns (Biggs et al., 2015), but major nexus challenges are faced at local levels (Terrapon-Pfaff et al., 2018). Thus, 'larger scale' extraction and consumption of natural resources may lead to depletion of natural capital stocks and increased climate risk with no equitable share of the benefits (Hoff, 2011; Rockström et al., 2009). Al-Saidi and Elagib (2017) showed the importance of exploring driving forces and interactions at different scales in the conceptual development of the nexus, emphasizing more case-study based recommendations in the reality of institutions, bureaucracies, and environmental stakeholders.
Response	However, when we develop this tool, we contacted the managers and engineers working in the OCP group and OCP policy center, and had a lot of discussion about the data, policy, and goals. Based on the meetings, we set the scenario variables such as increasing products and changing transportation method from train to pipeline.
Revision (Line 172-179)	Throughout the tool development process, the supply chain was verified with OCP and the OCP Policy Center in various ways: (i) during the data collection phase, through meetings with the OCP steering committee, financial managers, technical managers and engineers; and (ii) through follow ups with OCP Policy Center team (conference calls and email). The OCP Policy Center team shared with WEF Nexus Team their main concerns regarding the tool structure, based on input from the OCP technical team. The WEF Nexus Team used these shared concerns in their considerations of revisions to the tool structure and associated excel spreadsheets of the model. Specifically, the major aggregated processes and lines of productions were revised and identified in a functional supply chain to maximize the abilities and flexibilities of the model and ensure efficacy of the available data base for processes and production lines.
Response	The WEF-P Tool referenced the concept of WEF Nexus Tool 2.0. However, the details of methodology are quite different. For example, the key methodology in WEF-P is supply chain analysis including materials, transportation, and resources. Thus, we add more explanation of the framework of WEF-P tool and novelty of this tool.

Revision Notes

Revision (Line 149-154)	The developed WEF-P Tool, adapted from the WEF Nexus Tool 2.0 (Daher and Mohtar, 2015), considers the supply chain of final product in terms of its resource consumption, including the set of processes that pass materials forward (La Londe and Masters, 1994; Mentzer et al., 2001), and various organizations or individuals directly involved in the flow of products (Mentzer et al., 2001). It assesses the impact of various scenarios and possible responses to regional resource management needs. Table 1 shows the differences between WEF Nexus Tool 2.0 and WEF-P Tool in the context of variables, scenarios, analytical tools, and quantitative assessments.

Table 1 Comparison between WEF Nexus Tool 2.0 abd WEF-P Tool

	WEF Nexus Tool 2.0	WEF-P Tool
Variables and scenarios	• Self-sufficiency of produced crops • Type of agricultural production • Sources of water (groundwater, surface water, treated water and so on) • Sources of energy (natural gas, diesel, solar, wind and so on) • Trade portfolio (countries of import and amounts per country)	• Static and dynamic phosphate production • Transportation modes (train and pipeline) • Sources of water (groundwater, surface water, treated water and so on) • Water allocation between industry and agriculture
Analytical tool	• Food product base analysis • Food-centric interlinkages among water, energy, and food • Water and energy footprint based on product (ex. water footprint of crops)	• Process base analysis • Phosphate-centric interlinkages among production, transportation, and resource allocation • Water and energy footprint based on processes (ex. water footprint in washing process)
Quantitative assessment	• Water requirement for energy and agricultural production • Energy requirement for agricultural and water production • Land footprint for agricultural and energy production • Carbon emissions from energy used for water and food production • Financial cost	• Water and requirement for phosphate production and transportation • Carbon emission by energy used in product processes, water supply system and transportation • Dynamic production impacts on water and energy savings

Revision Notes

Comments 2

Reviewer's comments	2- Line 65: it is better to use the actual information as 2019 for the population growth and avoid using hyperlinks in the text as reference the same in the lines 68 and 70
Response	We applied your comment and revised it.

Comments 3

Reviewer's comments	3- Line 76 to 80: the author needs to add a reference for the quote
Response	We applied your comment and revised it.

Comments 4

Reviewer's comments	4- Part 2.1: from where came the differentiation of the different types of water and from which background the new water concept is coming? and is the wastewater used is coming from phosphate washing? If yes, are you sure that it is safe?
Response	In addition, OCP launched a plan to complete treatment plants for urban wastewater, primarily for industrial reuse in the mining area (capacity 5 million m³ yr-1), allowing using for washing phosphate (OCP, 2016b). The phosphate mining area is encircled by cropland, whose water is also supplied from the dam. In this study, we considered the allocation of treated water to phosphate industry and agriculture irrigation and Tian et al. (2018) showed the usage of treated wastewater from urban area for agriculture irrigation..

Comments 5

Reviewer's comments	5- Figure 1: the description of the figure is missing. Otherwise, there are two missing key concepts need to be considered: sustainability index and environmental index (related mainly with the Phosphate toxicity)
Response	WEF-P in this study focused on the estimation of water and energy based on supply chain analysis but the economic and environmental impacts assessment was not included. In addition, sustainability has a lot for meaning itself, and it is related to qualitative assessment, thus it is difficult to define what is sustainability. In previous version, we considered the availability as sustainability index. The availability index is calculated using maximum capacity and current consumption. For example, a large quantity of water available indicates 'available water', while a negative value of water availability indicates that water use has exceeded maximum capacity. However, at this version of tool, we focused on quantification of resource saving and put the availability and sustainability index to next version. It is limitation of this tool, and we mention this limitation in Conclusion. We revised the entire section "2.2.1 Overall Framework of WEF-P Tool"
Revision (Line 148-194)	2.2.1 Overall Framework of WEF-P Tool The developed WEF-P Tool, adapted from the WEF Nexus Tool 2.0 (Daher and Mohtar, 2015), considers the supply chain of final product in terms of its resource consumption, including the set of processes that pass materials forward (La Londe and Masters, 1994; Mentzer et al., 2001), and various organizations or individuals directly involved in the flow of products (Mentzer et al., 2001). It assesses the impact of various scenarios and possible responses to regional resource management needs. Table 1 shows the differences between WEF Nexus Tool 2.0 and WEF-P Tool in the context of variables, scenarios, analytical tools,

Revision Notes

	and quantitative assessments. Both the Tools offer a platform for development of the analytics necessary to understand the trade-offs and catalyse a stakeholder dialogue (Mohtar and Daher, 2016; Mohtar, R. H. and Daher, 2014). The core of the WEF Nexus is that production, consumption, and distribution of water, energy, and food are inextricably inter-linked: decisions made in one sector impact the other sectors (Hoff 2011, Mohtar and Daher, 2012). The WEF Nexus Tool 2.0 allows holistic quantification of the impact of resource allocation strategies to support informed, and inclusive stakeholder dialogue between policy makers, private sector firms, and civil society (Daher and Mohtar, 2015). Each stakeholder becomes involved at different stages and scales in the decision-making process. In the WEF-P Tool (Figure 2), water resources are shared between the phosphate industry and agricultural interests in the region of study. Sustainable water management must holistically consider the allocation of water resources for both industrial production and agricultural irrigation. New water (treated urban wastewater) has the potential to contribute significantly to bridging water and food gaps (Mohtar et al., 2015). However, it carries an energy footprint that must be considered when increasing local food production. Potentially, agriculture's demand for water competes with those of a growing industry. The Tool quantifies the use of water and energy and the amount of CO_2 emitted for each scenario. It also quantifies the water and energy savings resulting from choices made regarding transportation scenarios. The Tool assesses the effects of decisions of dynamic management of phosphate production as these impact water and energy securities. The WEF-P tool can assess various scenarios and help account for interdependencies between food and industrial production, and between water and energy consumption, thus allowing the trade-offs associated with potential resource allocation pathways to be quantified. Throughout the tool development process, the supply chain was verified with OCP and the OCP Policy Center in various ways: (i) during the data collection phase, through meetings with the OCP steering committee, financial managers, technical managers and engineers; and (ii) through follow ups with OCP Policy Center team (conference calls and email). The OCP Policy Center team shared with WEF Nexus Team their main concerns regarding the tool structure, based on input from the OCP technical team. The WEF Nexus Team used these shared concerns in their considerations of revisions to the tool structure and associated excel spreadsheets of the model. Specifically, the major aggregated processes and lines of productions were revised and identified in a functional supply chain to maximize the abilities and flexibilities of the model and ensure efficacy of the available data base for processes and production lines. However, the WEF-P Tool has limitations in assessing economic impacts such as cost and benefit analysis. This is because cost must include the price of water, which is still under discussion, and the price of products when analysing their benefits. Raw phosphate is transported to the manufacturing area and used in the production of various fertilizers that have different prices: this makes it difficult to set the price of excavating raw phosphate in the mining area. Sustainability assessment also has qualitative aspects in terms of environmental impact. The WEF Nexus Tool 2.0 applied the sustainability index based on resource capacity and availability, however, it is still a quantitative aspect. We should consider the meaning and definition of sustainability, both quantitatively and qualitatively, and then assess the index using the stakeholders' weights for the variables related to sustainability. Additionally, spatial and temporal scales should be included in a sustainability index. For example, the pipeline transportation system requires water, which is transported with products: the pipeline causes greater water use at the origin, but also provides additional water to the destination area. Also, the water requirement differs with temporal season, such as the water intensive agricultural production season. Thus, more research is needed for a sustainability assessment based on economic and environmental impact. However, the quantitative analysis is an essential factor for assessing sustainability, therefore, the WEF-P Tool focuses on quantification of 1) water and requirements for phosphate production and transportation, 2) carbon emissions by energy used in product processes, 3) water supply system and transportation, and 4) dynamic production impacts on water and energy savings.

Revision Notes

Comments 6

Reviewer's comments	6- In the site description: it will be good to have a general idea of the study area (location, climatic conditions: rainfall, temperature, wind, radiation, water resources, soil resources, agricultural activity, energy source) since the author involved the evapotranspiration calculation and water and energy footprints.
Response	We added the table of climate information.
Revision	(see Table 2 below)

Table 2 Climate information in Khouribga

Month	Precipitation ($mm\ m^{-1}$)	Temperature min. (°C).	Temperature max. (°C)	Relative humidity (%)	Sunshine hours ($h\ d^{-1}$)
Jan	56	3.8	17.3	72	5.6
Feb	65	5	19	76	5.7
Mar	94	7.2	21.8	69	6.4
Apr	70	9.5	25.3	67	7.4
May	32	12.5	29.3	55	8.8
Jun	9	16.6	34.5	48	9.8
Jul	2	19.8	39.7	39	10.9
Aug	7	20	39.6	37	10.3
Sep	12	17.5	34.5	47	9.1
Oct	27	13.5	29	58	7.6
Nov	71	8.8	22	70	5.2
Dec	81	5.1	18.6	71	5.5

Comments 7

Reviewer's comments	7- Part 2.2.2 the author underlined mainly the different steps of phosphate production and missed a good explanation of the footprint calculation and the data gathering methodology and date frame of the collected data. For the CO2 emission, the author linked it only with energy use, but he forgot to mention the importance of having a healthy soil can play a crucial role in carbon sequestration.
Response	We agreed there are limitations in calculation of CO2 emission. To calculate CO_2 emission, we need to measure real emission in each process in supply chain but it was limited to measure CO_2 emission in mining area. In addition, CO_2 emission in crop area is related to soil and crops, and it is another level of research. Thus, we limited CO_2 emission which is emitted by fuel energy use by machinery (direct emission) and electricity generation in power plants (indirect emission), and the reference CO_2 footprints were applied, as shown in Table 2.
Revision	(see Table 2 below)

Table 2 CO_2 emission by burning fuels and generating electricity

CO_2 emission by burning fuel		CO_2 emission by generating electricity			
Sources	CO_2 emission[1] (kg of CO_2 L^{-1})	Sources	CO_2 emission by sources[1] (ton of CO_2 10^{-6} kWh)	Proportion of sources in Morocco[2] (%)	CO_2 emission (ton of CO_2 10^{-6} kWh)
Gasoline	2.59	Coal	1,026	43.4%	
Diesel	2.96	Petroleum	1,026	25.3%	
		Natural gas	504	22.7%	820.9
		Hydroelectricity	19.7	6.9%	
		Renewables	15.8	1.7%	

[1] U.S. Energy Information Administration (https://www.eia.gov)
[2] International Energy Agency, 2014.

Revision Notes

Comments 8

Reviewer's comments	8- Part 2.3: the author used the ETP requirement to calculate the irrigation water requirement which needs to be revised and does the used data in this calculation are reflecting the exact situation of the study area?
Response	Irrigation water requirement was calculated using CropWat model, and not only evapotranspiration but runoff of rainfall was applied as well. We used the reference methodology (USDA SCS method) from CropWat explained in FAO No. 46 report. Thus, we added more explanation about irrigation requirement modeling based on ETc and runoff that is provided in CropWat model. Please find the addition explanation as below. We do not have exact data of agricultural area near mining area in Khouribga. First, we checked the agricultural area using MODIS-based global land cover data, found a lot of crop area near by Khouribga. However, we were not able to collect more data about exact area, crops, and irrigation system. Thus, we constructed the tool to be able to adapt the agricultural area as user scenarios. In other words, we assumed the agricultural area near by mining area and set the target production as user scenario instead of setting the agricultural boundary. It could be limitation in terms of feasibility but this tool is decision support system, thus it can provide results with various situation of agricultural production plans.
Revision (Line 307-314)	Irrigation water requirement was calculated by ETc and effective precipitation, as shown in Eq. (10). The effective precipitation indicated the precipitation except for runoff, and was calculated using the USDA Soil Conservation Service method (Eq. 11) (Smith, 1992). $IRReq = ET_c - P_{eff}$ (10) $P_{eff} = P_{tot}\,(125 - 0.2\,P_{tot})/\,125$ for $P_{tot} < 250\,mm$ (11) $P_{eff} = 125 + 0.1\,P_{tot}$ for $P_{tot} > 250\,mm$ where $IRReq$ is irrigation water requirement, ETc is the crop evapotranspiration, P_{eff} is effective precipitation, and P_{tot} is total precipitation.

Revision Notes

Comments 9

Reviewer's comments	9- Table 1: do you mean by plan data the plantation season or the date of data collection?
Response	It indicates the plantation season

Comments 10

<table>
<tr><td>Reviewer's comments</td><td>10- For the results and discussion, the choice of the scenarios should be clarified before</td></tr>
<tr><td>Response</td><td>To apply the reviewer's comment, we added more explanation of target scenarios and the section 3.1 Application of scenarios.</td></tr>
<tr><td>Revision
(Line 319-330)</td><td>3.1 Application of scenarios
Increasing the exportable phosphate products and changing the transportation system from train to pipeline are considered top priorities for OCP group. Therefore, we assessed the impact of increased production by applying the scenarios (Table 5). Until recently, dried phosphate was transported by train from mining to manufacturing site, but, in the near future OCP group will use only pipeline transport. The change of from train to pipeline can affect not only direct energy or water consumption by transportation system but also that of the total supply chain in the mining site. Consequently, the production processes for slurry and for rock consume different quantities of water and energy, so that the mode of transport also becomes a scenario to allow quantification of their respective water and energy requirements.
Therefore, we applied the scenario about transportation system which indicates the only usage of pipeline. Table 4 showed the scenarios combining production and transportation. The first two scenarios are related to the 'business as usual (BAU)' scenario for production in 2015 but changing the transportation system from Khouribga to the terminal station at Jorf Lasfar. The other scenarios are related to the increase in the production.

Table 5 Scenarios through combination of production and transportation system
<table>
<tr><th rowspan="2">Scenario</th><th rowspan="2">Phosphate production</th><th colspan="2">Transportation of phosphate products</th></tr>
<tr><th>by pipeline</th><th>by train</th></tr>
<tr><td>BAU</td><td rowspan="2">Production in 2015</td><td>40 % of total phosphate</td><td>60 % of total phosphate</td></tr>
<tr><td>Scenario 01</td><td>100% of total phosphate</td><td>None</td></tr>
<tr><td>Scenario 02</td><td rowspan="2">50% increase of phosphate export</td><td>40 % of total phosphate</td><td>60 % of total phosphate</td></tr>
<tr><td>Scenario 03</td><td>100% of total phosphate</td><td>None</td></tr>
</table>
</td></tr>
</table>

Revision Notes

Comments 11

Reviewer's comments	11- Figure 3: it will be better if you consider the ETP to extract good information
Response	We applied your comment, and made additional graphs.

Revision

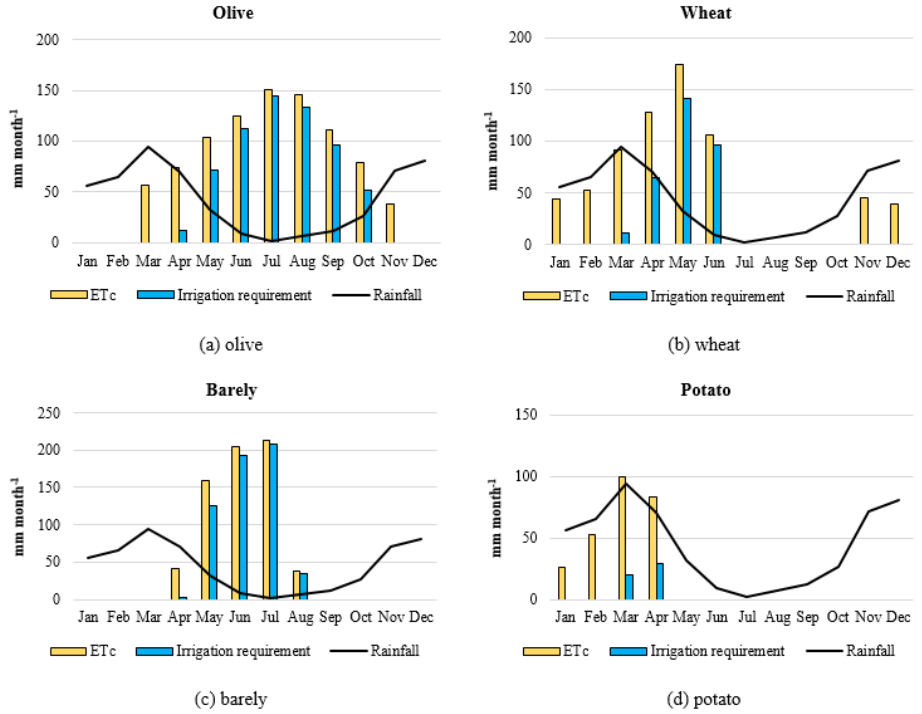

Figure 5 Monthly irrigation water requirement and rainfall in Khouribga

Comments 12

Reviewer's comments	12- Line 64: (Taleb 2006) a comma is missing
Response	We revised it.

Comments 13

Reviewer's comments	13- Line 74: (OCP 2013) a comma is missing
Response	We revised it.

Comments 14

Reviewer's comments	14- Figures from 1 to 6: add short descriptions
Response	We added the short descriptions.