Determining sustainable production limits for green growth

As countries develop and their populations increase, they exert pressure on the available natural resources, largely to meet the growing demands for energy, commodities, food and water. River basins are particularly vulnerable because they are rich in biodiversity and represent an important source of fertile lands for the growing of crops, timber, fuel and for fresh water. In many basins, people also often live and work in large concentrations. As a result, some ecosystems have become so degraded that groups of people and communities have been displaced, pointing to the strong need to improve the management of river basins in a sustainable way.

Scientists from Wageningen UR have been carrying out work to help build interactive scenarios at the local scale and basin scale in order to identify the limits to production growth and the pathways to sustainable intensification. The tools presented, developed in collaboration with the researchers from the various Wageningen UR institutes and other scientific bodies, support participatory planning processes and help determine demand for ecosystem services and environmental flow (Box 1). The Green Economic Growth approach is applied as one of the pathways to sustainable development for a more food secure future (Box 1). For this to be successful, a whole host of stakeholders, including policy- and decision-makers, water managers and smallholder farmers must play an active role in the process.

Sustainable production limits

Healthy ecosystems provide essential services that are vital to our very existence (Box 1). Maintaining a good balance in the ecosystem service is critical as actions to increase one ecosystem service may lead to the degradation of other services. River basins have different sustainable production limits and these limits change over the course of time. With each innovation and new agribusiness opportunity, total economic water productivity changes, leading to different multiple benefits and trade-offs.

Tipping points mark moments where additional pressure on resources can cause severe, sometimes irreversible damage to the environment and to the river basin, in particular, and set back sustainable

Box 1: Key concepts and terms in considering sustainability thresholds

Ecosystem services (ES): these are defined as the direct and indirect contributions of ecosystems to human well-being. The Millennium Ecosystem Assessment categorises ES into four main groups: provisioning services (e.g., food, water, raw materials, genetic resources); habitat resources (e.g., maintenance of life cycles of migratory experiences and genetic diversity); regulating services (e.g., air quality regulation, climate regulation, moderation of extreme events, regulation of water flows, erosion prevention); cultural services (e.g., aesthetic information, opportunities for recreation and tourism, spiritual experience, information for cognitive development) (Millennium Ecosystem Assessment 2005)

Environmental flows are described as '…the quantity, timing and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems' (Brisbane Declaration 2007)

Green Economic Growth (GEG) is described as an effective strategy to stimulate sustainable economic growth in rural and urban areas to ensure poverty eradication, food supply security and improved quality of life for all without the overexploitation of natural resources of soil, water, biodiversity, energy and cultural capital. This involves looking at the best use of local resources to identify new opportunities and to search for the integration of value chains and new markets.
GEG has received worldwide attention within the context of Rio+20 (the United Nations Conference on Sustainable Development) and has been put forward as a tool to address the financial crisis as well as promote sustainable development (Alterra Wageningen UR n.d.)

development efforts. To avoid an overexploitation of water resources, the sustainability limits for production must be taken into account (Bogardi et al., 2013; Röckstrom et al., 2009). In situations where systems are close to tipping point, increased water consumption should be avoided by all means. So, if the demand for water resources exceeds availability, tough decisions have to be made on the most desirable use of water. Unfortunately, decisions about land and water resource allocation are at times made by governments in response to specific interests. In addition to this, the appropriate mechanisms to govern the allocation of scarce water are often missing. Knowledge partners are, however, well-equipped to bring the wider socio-economic effects of alternative land and water allocations into the decision-making process.

Assessing river basins

The framework outlined in figure 1 showing the principle steps for assessing sustainable production thresholds of river basins. It depicts how an inventory of information (gathered in part using participatory approaches) for local interventions as well as for measures at the basin scale can be used to predict water availability and family income, key parameters for sustainable and inclusive growth. Other key indicators such as soil fertility and biodiversity changes can also be determined.

The researchers have been using the framework along with a number of tools to compare impacts across alternatives, for example, to determine the consequences of land use change on water availability or the crop potential in a river basin. Four tools and how they have been used are presented:

Nile-AM

Wageningen UR (Alterra and LEI) recently developed the Nile Agricultural Model (Nile-AM) under contract from the Nile Basin Initiative (NBI), a regional inter-governmental partnership between the Nile riparians. This model is part of the Nile Basin Decision Support System (NB-DSS), which is a tool meant to support sustainable river basin development and more productive and sustainable agriculture in the region. Nile-AM integrates state-of-the-art descriptions of hydrological, biophysical and economic processes. It comprises two modules: a Crop Productivity model using the Food and Agriculture Organization's (FAO's) AquaCrop (FAO n.d.) at its core, and a modified (regional) version of the MAGNET model (Woltjer et al., 2011), a tool commonly used to simulate the impact of agriculture, trade, and land policies on global economic development.
Nile-AM has the functionality to define Agricultural Production Zones and to provide options for crop allocation. It considers the spatio-temporal water availability for agriculture and calculates final crop production. The modified MAGNET model is then used to determine the balance between agricultural production and demand, followed by a calculation of trade and its impact on other sectors of the economy. All the interactions between land, water,

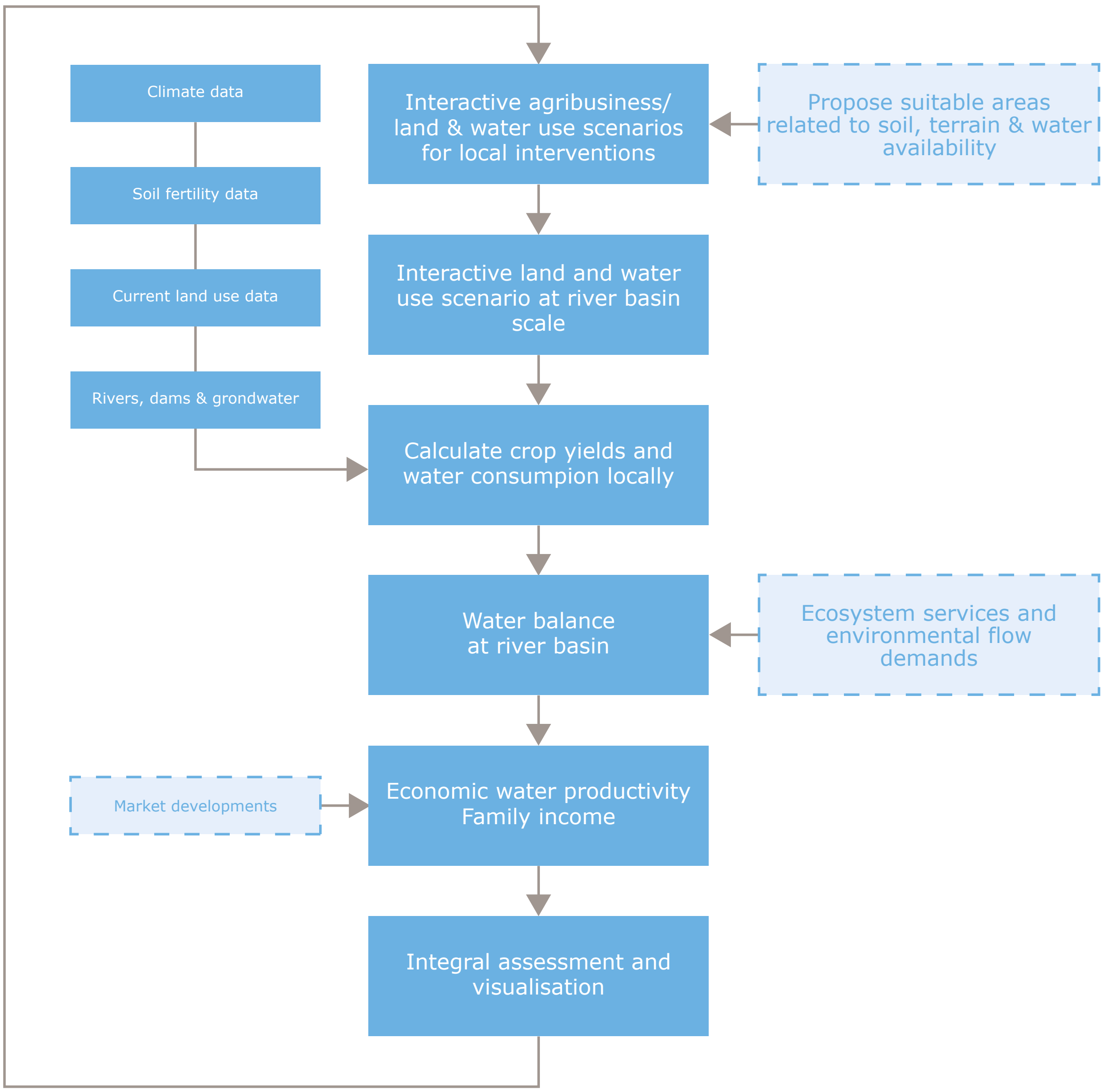

Figure 1 Integrating interactive scenario building with quantitative assessment tools is key to developing more realistic predictions on possible water consumption in the future. By addressing inputs on ecosystem services and market developments, the results from the scenario building can be translated into key indicators for inclusive growth. Reiterations need to be done when new opportunities for growth are detected.

and socio-economic development can be done interactively. Nile-AM is highly scalable and can be easily applied elsewhere. Its basic components are available in the public domain and are widely used by scientists and practitioners alike. As a result, there is an excellent support base as well as a high degree of confidence in the use of the model.

Description SIMGRO-WOFOST-QUEFTS

A chain of bio-physical simulation models was developed by Alterra for the Limpopo river basin (shared by Botswana, Mozambique, Zimbabwe and South Africa). The main aim of the models was to determine crop production potentials in order to support local economic development.
The Limpopo river basin can be characterised as river basin, where only a small percentage of the land is irrigated. Future extension and intensification of irrigated agricultural development may collide with nature conservation (e.g., well-known Kruger Park). The main challenge in this region, suffering from water scarcity, is to reconcile water demands from the various sectors with demands arising from new investments in agriculture. The model chain consists of a hydrological model SIMGRO (Querner et al., 2008, 2014), a crop growth model WOFOST (Supit et al., 2012), and the QUEFTS model (Janssen et al., 1999), which assesses the nutrients available to crops – all the elements needed to determine crop production potentials.

Description QUICKScan

QUICKScan is a participatory method, (supported by a software tool) used to enhance exploratory dialogue in a facilitated workshop-setting with

policy-makers, experts and other stakeholders. Typically, QUICKScan is used to scope, develop and assess alternative policy options and/or spatial plans. During the workshop, the impact of alternative options is visualised using the knowledge of participants.
QUICKScan was developed by Alterra and the European Environment Agency (EEA). It has been used: in the Netherlands for Dutch regional studies; to conduct several pan-European assessments for the European Commission (such as Green Infrastructure, Eco System Services, Natural Capital, Urban sprawl); for Mapping of Ecosystem services with several European member states. The method has also been used in Latin America (for soybean expansion), Africa (for social resettlement schemes), and Asia (for wetland conservation). For further details see: http://www.quickscan.pro.

Interactive water indicator assessment tool to support land use planning

Wageningen UR and WaterWatch developed a tool to support land and water managers in identifying and assessing scenarios for land development. The tool is an interactive, geographic information system (GIS)-based tool in a web-based environment. It uses various water-related indicators and is mainly intended to be used to support discussions. Stakeholders can use it to easily identify and evaluate scenarios and rapidly assess whether policy goals can be achieved or not. Ecological requirements have been included as 'ecological flows' as no consensus indicators are available. The data layers on which the tool is built comprise: land-use, rainfall, satellite image derived from actual evapotranspiration and biomass, market prices for produce, various production costs, and employment statistics. The instrument has been successfully applied in stakeholder meetings in the Incomati river basin, which is shared by South Africa, Mozambique, and Swaziland (Hellegers et al., 2012).

Interactive scenario building to support decision-making

Actual changes in water consumption are driven by land use change, and hence by those who invest in production, agribusiness, and in the innovation of value chains. Developing scenarios of sustainable production limits, which reflect future land use as realistically as possible, will help those in charge to make improved decisions towards promoting the sustainable development of river basins. Involving stakeholders in scenario building is critical, even though experience in participative modelling has shown that it is difficult to engage with them when it comes to the concrete development of quantitative scenarios. Classical approaches to inquiry, which involve discussing with stakeholders and then processing their answers as input into simulation runs and then discussing the results again with stakeholders, provide a lot of flexibility, but the iterations take time. GIS information systems, on the other hand, provide a good overview of the general trends and threats and assessment of scenarios, and are more interactive, but are often not specific enough to consider individual production systems and the agribusiness concept. They are therefore less suitable to predict the effect on local labour conditions and increase in family income. Existing tools are also more bound to pre-defined scales – they either focus on the detailed analysis at the field scale or provide overview information at the river basin or regional scale.

Interactive map tables can provide new opportunities to support participatory inventory of upcoming investment plans and land use changes, providing governments with the valuable information they need to make sound decisions. They provide new opportunities to link participatory scenario building with a underlying quantitative assessment at local scale and basin scale.

Modern visualisation techniques can also support the private sector to visualise planning, to identify positive impacts for regional development and to create stronger ownership to develop projects. Experience, however, is needed on how to involve the private sector in planning processes and in how to handle strategic and sensitive information to determine what can be shared and what cannot be shared. Further, 'win-win' approaches need to be developed so that the private sector can benefit from more reliable information for planning and so that the public sector can have a better insight into upcoming changes and demands for natural resources at the basin scale. Only then, can the sustainable production limits be defined for a specific intervention.

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