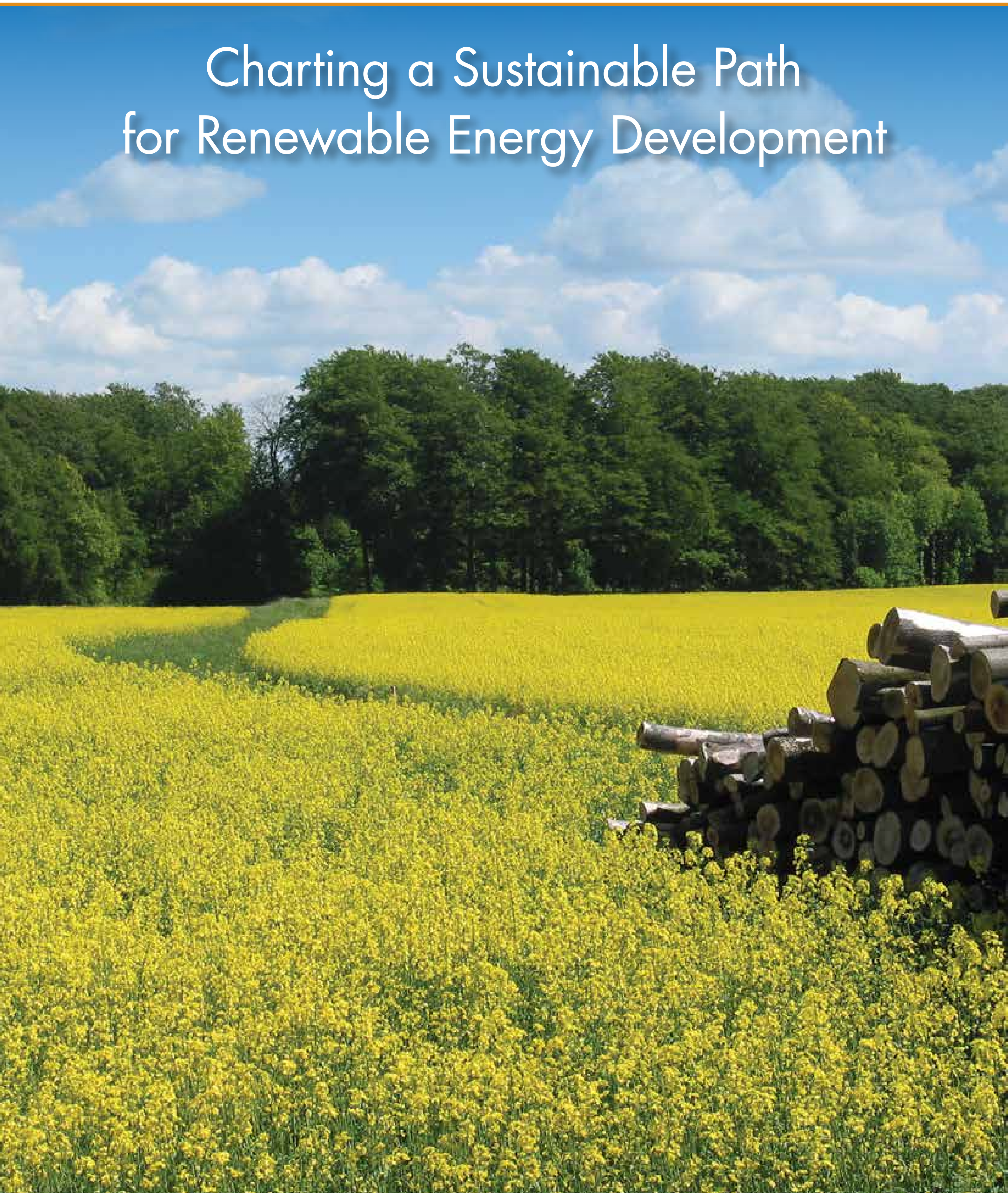
SIWI

SWEDISH WATER HOUSE

Policy Report

Charting a Sustainable Path for Renewable Energy Development



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Introduction

Global energy demand is in a state of flux. A 26 per cent population growth as well as an average global economic growth of 3.5 per cent until the year 2035 are underlying drivers (IEA, 2013). Consequently global energy demand will increase by 40 per cent during that period. Renewable energy will show the fastest relative growth during this period but will, nevertheless contribute a minimal share of total energy supply during the same period. Fossil fuels will dominate the energy mix with the likely impact that global targets on curbing global warming will be missed by a substantial margin (Ibid). When looking at total primary energy demand, hydropower and biomass are likely to continue to make up the dominant sources among renewable energy sources within the projection period (Ibid). Both energy sources are also vital components to Sweden's energy supply.

The cluster group on water and energy linkages has been made up of a range of actors representing diverse interests and sectors related to bioenergy and hydropower. As part of its mission the group has explored perspectives, shared knowledge and moved forward the understanding of key issues related to aspects of the water and energy nexus, the concept describing the interdependencies of water and energy.

This policy report captures perspectives of both hydropower and bioenergy relevant from a Swedish perspective as well as an international one. Consequently the report has been divided into two sections, one focusing on hydropower development and the other on bioenergy. It conveys collectively generated knowledge and recommendations on what are two prioritised areas in the current energy debate, deliberating the most live issues regarding the two.

The hydropower section provides fresh perspectives on what is often a contested form of power generation. The many advantages of hydropower are elaborated on as are the negative consequences, in order to provide the background to recommendations presenting a balanced take on how hydropower can be produced in the most sustainable manner as continued efforts in the development of other renewable energy types continues.

The bioenergy section gives insights to the sometimes very complex relationship between this type of energy and water resources. The section also extensively elaborates on the growing involvement of private sector actors as energy producers, often in developing countries, competing for precious water and land resources. The chapter puts forward advice and recommendations specifically relating to companies receiving support from development assistance organisations and other financial institutions, in order to provide a first level understanding on how this type of cooperation can be most effective while safeguarding environmental and social sustainability.

Photo: Brit-Louise Andersson

Hydropower: Renewable and Potentially Sustainable

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The role of hydropower

Hydropower has been and is a major renewable energy source in the global energy mix. In terms of electricity production, the fastest growing type of end use energy, hydropower constitutes the largest power generator among renewables, making up little over 16 per cent of the world's electricity production and close to 85 per cent of total renewable electricity production (IEO, 2013).

There are several reasons as to why hydropower is a preferred choice among renewable energy types. Foremost, it is a technology mature energy type with a comparably high energy conversion rate which, coupled with other characteristics, makes hydropower a cost-efficient option. Other aspects of hydropower are beneficial from a development perspective. Positive outcomes are however subjected to specific circumstances such as climate, project design, reservoir characteristics and existing social conditions in and around any given hydropower site. Obvious positive outcomes are the multi-purpose function of hydropower facilities i.e. reservoirs. The ability to provide additional functions besides power generation, such as drinking water supply, irrigation water or possibly flood control functions, makes this kind of infrastructure investment sensible from a general development perspective. Comparably clean and renewable, hydropower plays a part in itself to generate (near) CO_2 neutral electricity (however research on emission levels differ and cannot easily be generalised. More research is needed to further establish the possible contribution from hydropower). Furthermore, it is vital in order to enable augmentation of other intermittent renewable energy types to the electric grids. Intermittent in character, particularly solar and wind power (currently preferred renewable options) need back-up power in order to fill generation gaps. Only few current energy options have the potential to function as energy storage and have the ability to match fluctuating demand curbs over time. Presently, this can best be provided through natural gas and large scale hydropower (similar benefits for small scale hydropower are not as evident). Among the two, hydropower is the faster and cleaner alternative. However, it is clear when considering that there are only two, more or less, competitive (but possibly less sustainable) options that alternatives are needed. Therefore, ongoing research efforts related to alternative energy storage functions must be prioritised and sped up.

Outlook

Hydropower has had great impact in enabling development and economic growth by providing reliable electricity and other benefits to growing cities and regions. The global potential to develop hydropower assets is still considerable. The current global technical potential translated into capacity stands at 3750 GW, and the annual growth rate of installed hydropower capacity is 24.2 GW (IEA Technology Roadmap, 2012). China dominates this growth together with Brazil, USA, Canada and Russia (Ibid). Hydropower will also see substantial growth in other parts of the world, not least in developing countries as there is huge potential still to be exploited, with Africa only using 8 per cent of its technical potential. More developed parts of the world still holds vast development potential including Europe. Alongside the possibility of generating more power by tapping existing potential, conflicts can arise in terms of water allocation for other uses with potentially adverse effects on biodiversity. Investments in hydropower have increased substantially over the last decade.

Hydropower options

Hydropower is not a unison concept. The techniques used to harness kinetic energy from water and convert it to electricity differ as do the various schemes making up typical hydropower projects, thus providing alternatives when it comes to project implementation.

Some principle concepts related to hydropower project designs are described below:

Reservoir hydropower

Hydropower is often generated in connection to a reservoir or storage facility. Water storage provides security in terms of power generation, since a reservoir can store years of average inflow water. This allows power production to follow demand curve variations over time, as more water can be released to boost power production. Reservoir-combined projects are also typically ones that can offer multi-purpose functions. The environmental cost for the reservoir is site specific. Evaporation becomes a major issue. The water consumption due to evaporation from a dam can vary as much as from 1 to 3,000 litres/kWh generated. The global average is 80 litres/kWh. This should be compared to e.g. nuclear power that typically consumes 4-7 litres/kWh due to evaporation (Olsson, 2012). Reservoirs play a crucial role in the adverse effect of silica retention, a key compound in all seas' nutrition balance.

Run-of–river (RR)

RR systems do not use storage facilities (however small pondage reservoirs can be used to permit short term storage and power generating flexibility). RR systems divert portions of main river stems for power generating purposes after which the water is reconnected to the main river branch. Particularly RR systems of lesser scale, using no pondage to block river flows, are considered to have less negative environmental impacts.

Pumped storage (PS)

PS hydropower is a version of storage hydropower where water is pumped from a lower reservoir to a elevated one using cheap electricity (favorably during times when power demand is not high thus cheaper) and then released back to provide power to the grid in times of high demand and consequently high value, allowing systems to be profitable although being a net consumer of energy. The function of PS plants means that they do not necessarily need to obstruct rivers the same way regular storage plants do, since storage facilities can be completely artificial (however this is rarely the case). PS plants in natural river environments can cause serious damage which indicates that development of alternative energy storage with less environmental impact must be sped up. According to IHA annual report (2013) PS is planned for China (1,500 MW), East Asia outside China (470 MW), and Europe (324 MW). This should be compared to planned "pure" hydropower in China (14,400 MW), East Asia outside China (3,329 MW) and Europe (532 MW).

Hydropower in cascades

Storage hydropower and RR systems can be combined in sequence to increase potential. This is usually done with a storage function upstream followed by a series of RR plants (or smaller reservoirs). The regulation function provided by the first dam boosts generating potential in subsequent plants.

Scales

Hydropower can be produced at different scales. In general, small scale hydropower includes plants with a production capacity of less than 10 MW. However, definitions differ in places and sometimes capacities of up to 50 MW are also considered small scale. Although they use the same power generating principles as larger hydro plants, small scale facilities are often thought to have very limited environmental impact on their immediate surroundings compared to large scale plants, but it must be understood that even smaller plants often obstruct natural river flows.

Controversy

Hydropower is a controversial energy type. The substantial benefits described above often come at a price paid in negative environmental and social impacts, risking to overtake positive outcomes. When projects – which was often the case in early days development – were implemented without sufficient environmental/strategic impact assessments or response mechanisms (mitigation measures and compensation schemes) there were severe negative consequences.

Environmental impacts

Construction of dams means barriers across natural river flows, changing aquatic systems from lotic to lentic. This can have adverse effects on existing flora and fauna locally around a dam site and also far-reaching consequences in connected ecosystems. Furthermore, quality and quantity of water risks being affected from dams. Stored water released upstream from reservoirs to downstream areas is often changed in terms of temperature, oxygen content and chemical composition, thus changing its productive potential in downstream areas. During the initial period, when a reservoir is being filled up, there is risk of less water reaching downstream areas, resulting in dry river beds and affected ecosystems. There is also some evidence to indicate that dams can be a source of greenhouse gases, primarily methane gas and to some extent carbon dioxide, the production of which is associated with the filling of the reservoir, flooding vegetative areas inducing the rotting of biological material. Contemporary research also shows that dams and reservoirs are a main driver for silica retention in surrounding seas.

Social impacts

Dam construction brings several social challenges. Throughout the history of dam construction, hundreds of thousands of people have been forced to move to make room for reservoirs and areas to be flooded for the purpose of constructing dams. Loss of traditional livelihood opportunities often leave affected community members with no clear alternative of generating income, thus creating an indefinite negative impact from the resettlement phase. Health implications are also evident in relation to the construction of reservoirs. Changing free flowing water systems to stand still systems means the creation of habitats for species that can serve as hosts for various diseases, malaria being the most prominent.

It is important to understand that unlike the benefits from dam construction, the negative impacts are often more difficult to assess in monetary terms as systems for this are lacking. This is true for environmental impact assessments of all types of environmentally degrading activities. A typical example can be the loss of traditional lands that hold specific importance for particular habitants of a certain area.

Photo: Nathan Sudds/www.sxc.hu

The Swedish Context

Current status

Sweden is in many regards a "hydropower nation", showcasing both the significant values generated by hydropower but also hosting a set of experiences from negative aspects of related project development.

Sweden presently relies on hydropower for approximately 14 per cent of total energy production (Energimyndigheten, 2013). Hydropower accounts for about 45 per cent of Sweden's electricity generation, although there is substantial potential for both wind and solar energy to be developed further (Ibid). The ability to generate hydroelectricity has a high potential specifically in the northern areas of Sweden. Much hydropower is produced by plants located on major rivers such as Lule älv, Indalsälven, Ångermanälven och Ume älv (Ibid). The transfer of the power via transmission lines to the southern industrial development hubs is a major reason for the prosperous economic development enjoyed for the last century.

Almost all development of national hydro resources had many negative consequences, not least for the indigenous sami population in northern Sweden. The sami lost opportunities for livelihood generation as well as access to traditional cultural areas, and many accounts of abuse have been documented (Öhman, 2011). Land ownership and compensation issues are still a contested topic in these areas. Consequences of storage and hydropower development, such as altered water quality and loss of local fauna, are still felt in the northern parts of Sweden. Loss of biodiversity has been a consequence in many hydropower projects in Sweden.

Hydropower is produced by approximately 2,100 hydropower stations of which most can be considered small scale.

Regulations

Sweden has implemented environmental legislation in sequences, preventing hydropower construction on some major rivers. Although there is great energy potential, these rivers currently have no hydropower installation on them. Hydropower construction is not considered an option in current energy policies. The discussion of continued hydropower development in Sweden came to an end in 1970 when the government decided not to sanction power plant construction along Vindelälven. Since then, hydropower has been largely absent from the domestic debate on energy production and growth. EU directives regarding energy and water development set limitations to how hydropower can be developed among EU countries. The 2009 directive "On the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC" does not include hydropower as an option for future energy development in the EU region (2009/28/EC). Likewise, the EU Water Frame Work directive in force from the year 2000 does not consider the energy potential and function of water resources (2000/60/EC). In parallel, Sweden abides by the EU directive (EG, 2009) which demands that close to 50 per cent of Sweden's energy mix should be made up of renewable energy by the year 2020, a task that therefore must be assessed with other renewable sources than hydropower, such as solar energy and wind turbines, to add to the overall sustainability of Sweden's energy production. A recent investigation issued by the Swedish government to ensure that hydropower production is in accordance with Swedish and EU environmental standards, could impose limitations to existing production (Delbetänkande av Vattenverksamhetsutredningen, 2013). This has once again triggered intense discussions about the environmental impacts of hydropower and its importance to Swedish electricity generation and highlights a possible need to reassess old concessions for hydropower production to make sure it is in accordance with existing legislation (Rudberg, 2013).

We recommend

- That hydropower is considered as renewable energy does not necessarily imply that hydropower is a sustainable source of energy. Development of hydropower should therefore be put in a broader perspective at an early stage in which social, environmental and economic issues are considered.
- Current trends in hydropower development (construction/investments) globally (not least in developing regions) suggest that hydropower cannot be marginalised in the current discourse on energy development. Its benefits and negative impacts need to be sufficiently understood and assessed in order to support the best possible types of project development. This must be combined with the evaluation of other possible renewable energy sources or projects that could possibly better achieve social, economic and ecological goals.
- Current energy development trends and policies at the global level suggest a desire to increase the level of renewable energy in the energy mix. This suggests favorable timing to inject fresh perspectives to the dialogue on hydropower and reassess its role among energy generating options, taking in consideration all social and ecological adverse effects.
  - Hydropower as a function for energy storage and regulation needs to be assessed based on existing and future energy demand as well as agreed targets for increased deployment of renewable energy sources.
  - Development of alternative "energy storage" functions must be sped up in order to diversify options to enable the augmentation of renewable energy to the energy mix. Investing in continued research and development in this field is crucial.
  - A fresh evaluation of risks and benefits from hydropower should more comprehensively include the potential to utilise the least harmful types of RR and PS systems in terms of power generation capabilities and possibly reduced environmental impacts. Such an evaluation is also recommended for already built systems and plants.
  - When old permits to implement hydropower are renewed in accordance with EU and Swedish environmental legislation, options to reduce or increase hydropower generation need to be balanced against environmental and social tradeoffs. The assessment process determining this must include and absorb considerations from all relevant stakeholders (Rudberg, 2013).
- Assessing the potential of increasing output from existing plants through refurbishments, alternative operational procedures and other measures, in combination with state of the art mitigation measures to reduce environmental effects, should be a prioritised measure.
- Accepted tools and frameworks for assessing the sustainability of hydropower should be used in all steps of project development in order to secure that a project is on track.

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Photo: Alfred Borchard/www.sxc.hu

Bioenergy and Water: Maximising Gains, Minimising Risks

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Outlook

Bioenergy and especially biomass has always played a major role in energy supply in large parts of the world. The traditional, most often unsustainable, use of firewood for heating, lighting and cooking is still the only option for many in terms of energy supply, constituting 80 per cent of all bioenergy use globally. The remainder is normally described as "modern" or "refined" bioenergy where bioenergy feedstock is processed into different solid, gaseous or liquid biofuels.

As part of the overall increase in energy demand over the coming decades, the demand for bioenergy is growing rapidly. The desire to increase the renewable energy part of the global energy mix and phase out fossil based fuels puts special focus on bioenergy, including biofuels. Biomass-based fuels presently constitute the most viable renewable option to replace fossil fuels as the dominating fuel type in the transport sector. Such a transfer would contribute in the struggle to curb current climate change trends.

A second benefit would be to lessen global dependence on a single fossil fuel type, controlled by a few actors in the world and with ever increasing prices.

These factors combined have created a momentum and surge in investments in biofuel production in many nations, providing opportunities in many sectors including forestry and agriculture. Additionally, it has triggered policy support and public support through inter alia development assistance e.g. public funding.

Bioenergy and water

The sustainability of bioenergy production and its relation to water resources have come in focus as demand has increased, linking it to the wider system discourse connecting water, energy and land resources utilisation. The bioenergy production chain, both in terms of growing different types of feedstock as well as the industrial processes required to produce various kinds of biofuels, sometimes requires substantial amounts of water. The feedstock production can be particularity water consuming.

Production of bioenergy feedstock does commonly not require abstraction of surface or ground water resources for irrigation since it is part of rain fed agriculture and forestry. However, there can still be implications in terms of less water resources available downstream in a given river basin as precipitation is consumed in plant evapotranspiration processes, resulting in reduced run off of water and groundwater recharge potential. Since the water consumption is strongly linked to the processes and practices of producing the feedstock/raw material, there is substantial opportunity in applying targeted measures tied to the sustainable generation of these.

Water consumption levels cannot easily be generalised (and thus it should be done with caution) however global aggregated averages of water consumption related to bioenergy and food production are often hundreds times higher than those of other primary energy types.

An overarching observation is that effects on water by bioenergy projects are site specific, determined by many factors ranging from type of feedstock produced, climate circumstances, agriculture/forestry practices deployed, efficiency of supporting water conveying systems (in case of irrigated production), availability of infrastructure, government regulations, overall level of development as well as overall land and water management systems directly or indirectly influencing a specific site.

It is however clear that a lack of policies, laws and regulations, water shed management as well as unsustainable project implementation practices, that risk reducing the quantity and quality of water at the river basin level, can have severe negative impacts on existing ecosystems as well as local communities depending on ecosystem services for their livelihood.

Thus, incentives to promote bioenergy projects and the related project management and engineering design systems can directly and/ or indirectly lead to positive or negative effects on the state of water. It is essential that linkages between water-energy-land/food utilisation are taken into account when such incentives are considered or implemented. Systems for sustainable bioenergy project implementation should therefore incorporate the following elements as guiding principles (The bioenergy and water nexus– a complex relationship, 2013):

- Water intensity of the proposed activity.
- The state of water resources in the proposed area.
- Impacts of the proposed activity at the local level.
- Management and mitigation measures.

Based on the guiding principles, further strategic recommendations can be made, highlighting important aspects of sustainable water utilisation in bioenergy production:

- A watershed perspective based on principles of integrated water management should be incorporated in production processes in order to better consider competition for water and priority of actions on local, national or regional level.
- The use of metrics and accounting systems such as water footprints, water use efficiency and LCA can offer insights into water related consequences along the bioenergy supply chain. However, the use of such metrics in lieu of proper ecosystem impact analysis should be avoided since they might be misleading and irrelevant to achieving sustainable production and environmental security.
- Resources for Research and Development should be allocated to further develop useful tools to assess effects on water resources at appropriate scales, allowing for the inclusion of context/site specific considerations.
- Efforts to develop technology aimed at mitigation/minimising water impacts of production should be prioritised and beneficial synergies along the production chain (through measures such as irrigation water reuse and/or combined systems for feed, food and fuel production) must be capitalised upon.

Suggested further reading: "The bioenergy and water nexus", 2011, UNEP and IEA Bioenergy Task 43,"Bioenergy and Food Security the BEFS Analytical Framework, FAO 2010.

The role of the private sector

Investments in bioenergy have steadily increased in recent years as a consequence of ambitions to boost renewable energy and other alternatives to fossil based energy. It has been established that bioenergy projects can have negative impacts on water resources if they are implemented where sound relevant governance does not exist.

The link to private sector entities then becomes crucial, since various energy producing companies are often responsible for on-site project implementation as they seek to make profit from bioenergy feedstock production in areas where competition for water resources might be persistent.

This puts emphasis on how companies employ existing laws, policies, regulations, certification standards, sustainability frameworks, codes of conduct and compensation strategies. It also shows the need for a further dimension in how public- private partnerships could be shaped and how bilateral development assistance organisations could prioritise when reaching out to private operators with support for certain activities.

Identifying opportunities for collaboration

The central driver for any sustainable business is to make profit from activities undertaken. Financial support to these activities from other institutions, including public funding, aiming to deliver on targets of environmental and social sustainability must be carefully considered. The overall risks and benefits associated with delivering such support must be evaluated.

It is therefore important that the development assistance organisation has a clear and comprehensive strategy for how support can and will be allocated. General components of such strategy could favourably include clear definitions of:

- What are the desired outcomes from support to private sector operations?
- What characteristics, or minimum management systems, should a potential support recipient have in place in order to ensure that targets in line with environmental, social and health standards or guidelines are met?
- What activities carried out by a private sector entity, out of several options, could be liable for support from public funding sources? How can project ownership be defined to fit private sector entities as well as potential public funding or development assistance organisations wanting to support project activities?
- What plans, procedures and monitoring capabilities need to be in place in order to safeguard that potential support is utilised in the way it is intended? In other words, what management and communication tools and report functions could be used?

We recommend

Building on the bullets above, criteria can be developed to capture important aspects in evaluations of bioenergy producers, which could be further developed into a broader framework to be applied by development assistance organisations (and other similar entities) for engagement with the private sector. Proposed guiding criteria:

- Actors acquiring land and water resources for the purpose of bioenergy production, and that seek or are selected for public or development assistance donor support, should be able to demonstrate that activities to be supported strive towards achieving targets for sustainability; environmentally, socially and health wise e.g. a projects financial model should incorporate EIA/ESHIA processes as well as environmental, social and governance management systems, including management plans etc, as a minimum requirement and be in place prior to receiving support.
- Actors would have to demonstrate a financial model and project design that guarantees that sufficient resources are invested to deliver on such a system and that adequate competence and experience exists to implement measures that might become recommended as part of the management system.
- Implementation could be built on and streamlined through a development finance institution or similar certifiable institutions, associations or other networks with a mandate to render support to private sector activities by supporting responsible, sustainable investment or business development to foster poverty reduction, gender equality and other development goals.
- Public or development assistance organisation funding should not be viewed or used as direct business investment support, as these types of organisations are not generally involved in such activities, nor are they mandated to be. There are however several areas that can be opportune for the type of financial support offered by bilateral development agencies that can be seen as more directly contributing to strategic targets within their own operations.

Examples of these are (areas that can be disaggregated and detailed further):

Sub-national/local level

- *Infrastructure:* Support measures can be part of, but not limited to, infrastructure that is part of the general public infrastructure in an area of investment. However, strategic and targeted infrastructure investments to support the development of electricity and water supply, sustainable irrigation and transport networks (where these have been assessed as lacking but could be of major importance) are also key measures to enable efficient and sustainable production.
- *Capacity building:* Development assistance could be extremely useful as part of generating knowledge at the local level to strengthen capabilities and boost know how in farming communities/work force related to farming practices and resources management and consultation processes, among other areas.

Capacity building also entails developing local communities in terms of supporting access to adequate water resources, sanitation, education and other measures that play part in securing the overall project investment as well as fulfilling other development dimensions.

National/regional level

- Support to capacity development at the national level aimed at developing policies or guidelines for sustainable investment in agriculture and bioenergy.
- Support to capacity development at the national level aimed at ensuring fair, transparent and environmentally sustainable land acquisitions. This can also entail land administration and surveying as well as registration to ensure that small farmers' holdings are properly registered.
- Support to capacity development to develop national standards for compensation processes and schemes to groups affected by projects.
- There are also opportunities to produce services normally provided by external or "third party" entities including; legal assistance, training, network creation/multi stakeholder fora and independent project monitoring.

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Charting a Sustainable Path for Renewable Energy Development

Swedish Water House Cluster Groups

Cluster groups are small, interdisciplinary networks that bring together experts and practitioners by focusing on a specific issue for a period of two years. The meetings become an arena for stakeholders interested in building bridges between research, development, private sector, policy and decision making. Results can be varied, ranging from a final conference or policy brief to a report or even actual guidelines. All output is aimed at highlighting Swedish recommendations, practices, expertise or knowledge sharing which could be shared with international actors.

Read more about cluster groups at: **www.swedishwaterhouse.se/en/cluster_groups**

This report was produced by the parties illustrated below. It is directed to Swedish authorities, agencies and organisations engaged in Renewable Energy Development.

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