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Enabling Water-Energy–Food Nexus: A New Approach for Sustainable Agriculture and Food Security in Mountainous Landlocked Countries

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ABSTRACT

Majority of landlocked mountainous countries are poorly ranked in Human Development Index (HDI), mostly due to poor per capita agriculture production, increasing population, unemployment, expensive and delayed transportation including several other factors. Generally, economy of such countries substantially relies on subsistence agriculture, tourism, hydropower and largely on remittance etc. Recently, it has been argued that to utilize scarce suitable land efficiently for food production, poor inland transport, hydropower, irrigation, drinking water in integration with other developmental infrastructures, an overarching policy linking water - energy – food nexus within a country for combating water, energy and food security would be most relevant. Thus, in present paper it has been opined that promotion of such linkage via nexus approach is the key to sustainable development of landlocked mountainous countries. Major land mass in mountainous countries like Nepal remains unsuitable for agriculture, road and other infrastructure profoundly imposing food, nutrition and energy security. However, large pristine snowy mountains function as wildlife sanctuaries, pastures, watershed, recharge areas for regional and global water, food and energy security. In return, landlocked mountainous countries are offered certain international leverages. For more judicious trade off, it is recommended that specific countries aerial coverage of mountains would be more appropriate basis for such leverages. Moreover, for sustainability of mountainous countries an integrated approach enabling water - energy – food nexus via watershed-hydropower-irrigation-aquaculture-agriculture-integrated linking policy model is proposed. This model would enable protection of watershed for pico, micro, and mega hydro power plants and tail waters to be used for aquaculture or irrigation or drinking water purposes for food and nutrition security.

Key words: watershed, hydropower, agriculture, landlocked, economy

सारांश

मानव विकाश सूचकांकमा अधिकतम भूपरिवेष्ठित मुलुकहरु न्यून कृषि उत्पादकत्व, जनसंख्या वृधि, बेरोजगारी, महंगा र दुरुह यातायात लगायत कैयों अन्य कारणले गर्दा पिछडिएका मध्य पर्ने गर्द छन् । त्यस्ता मुलुक हरुका साना अर्थतन्त्र प्रायः निर्वाहमुखी कृषि, पर्यटन, साना जलबिधुत र रेमिट्यान्समा भर परेको पाइन्छ । हालै, त्यस्ता खाले मुलुक हरुको कृषि उत्पादनका लागि दुर्लभ उपयुक्त जमिन, यातायात संसाधन, जल बिधुत, सिचाई, खाने पानी जस्ता भौतिक पूर्वाधारहरु को संजाल लाई एकीकृत तवरले सम्बोधन गर्दा यी सबै पूरकहरुको बढी सिर्जनशील, सन्तुलित, चुस्त व्यवस्थापन बाट जल-उर्जा-खाधान्नको संजाल खासगरि भूपरिवेष्ठित मुलुकहरुमा दरिलो बनाउन बढी सान्दर्भिक हुने सोच प्रस्तुत भएको छ । जस अनुसार साना भूपरिवेष्ठित मुलुकहरु ज्ल-उर्जा-खाधान्नको संकट बाट मुक्त भइ दिगो विकाश तर्फ अग्रसर हुन् सक्ने तर्क पेश भएको छ । सामान्यतया, हिमाली मुलुकको अधिकाधिक भूखण्ड कृषि, सडक र अन्य यातायातका लागि अनुपयुक्त नै हुने र खाध, खानेपानी र उर्जाको आपूर्ति अधिकतम टड्कारो नै हुने देखिन्छ । तथापि, पर्वत र हिमाल शृंखलाहरुका विशाल भूखण्ड सदैव वन्यजन्तु आरक्ष, हरियो चरन, क्षेत्रिय र अन्तराष्ट्रिय जगतको जल, खाधान्न र उर्जा संकट मोचनका लागि जलाधार क्षेत्र, र जल आपूर्ति रुपी अविरल पर्यावरणीय सेवा प्रदान गरि रहेको हुन्छ । फलस्वरूप, त्यस्ता भूपरिवेष्ठित मुलुकले केहि सुविधा विश्व समुदाय बाट हासिल गरि रहेका हुन्छन । यस सन्दर्भमा बढी जायज र न्यायिक सुविधा प्राप्त गर्ने आधार त्यस्ता मुलुकमा अवास्थित पर्वत र हिमाल शृंखलाहरुका विशाल भूखण्डका क्षेत्रफ़ल् हुन् सके बढी सान्दर्भिक हुने तथ्यगत तर्क प्रस्तुत गरिन्छ । साथै, भूपरिवेष्ठित हिमाली मुलुकको दिगो विकासका लागि जलाधार-जलबिधुत-सिचाई-मत्स्य पालन, कृषि विकास जस्ता क्षेत्रको सयुंक्त प्रवर्धन हुने गरि नीति तय हुनु पर्ने आवश्यकतामा जोड दिइएको छ । यस मोडेल बाट साना, मझौला र ठुला सबै खाले जल बिधुत र साथै तहाँ बात निष्काशित जलको प्रयोग मत्स्य पालन वा सिचाई वा खाने पानी प्रयोज़नका लागि हुन सकी उर्जा, खाधान्न जस्ता आधारभूत आवश्यकताको सुरक्षा हुन सक्ने छन ।

INTRODUCTION

The most recent integrated development approach of interlinking water – energy – food nexus (Bizikova et al 2013, Gurung 2014, FAO 2014) has implication for efficient resource management in landlocked countries constrained by agricultural food production due to large landmass covered with snowy mountains terrains providing ecological services but unsuitable for general agriculture. Generally, development strategies which focus only one specific sector and do not consider interconnected risks often face unintended incidences that might impact first the poorest of the poor's water, energy and food security (WEF 2011). Water, energy and food are essential for human's well-being, poverty reduction and sustainable development (FAO 2014, Middleton et al 2015). However, the water, food and energy security in relation to rising global population and climate change is creating unsustainable pressures on earth resources (ADB 2013, Bizikova et al 2013, FAO 2014). Especially, on landlocked countries having landscapes with sloppy mountainous topography, subsistence agriculture, poor infrastructures for transportation (Jean-François et al 2007) thus to human development index. These might be some of reasons why the mountainous countries has been rated as the most vulnerable ecosystem impacting by natural calamities, hazards, climate change (NARC 2010, Gurung et al 2011, Pant 2012) and poor agricultural productivity.

Nepalese mountains are known as 'water tower of the world' playing substantial role for ecosystem services at regional and global scale (Viviroli and Weingartner 2004, KC 2009, Machhi 2010, Rasul 2012). Unfortunately these water resources have not been fully utilized

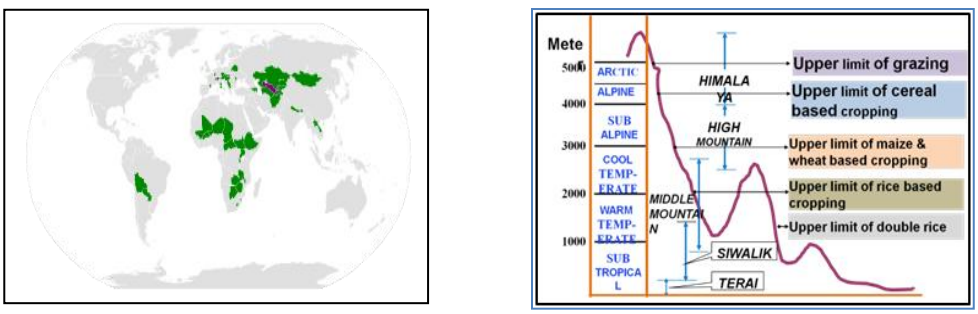
and internalized for sustainable development. Although hundreds of hydropower projects are being implemented, still Nepal faces heavy energy shortages, more than half population still living in darkness without electricity (Adhikari 2006).

Agriculture is generally known to be the major consumer of global freshwaters; approximately 70 percent are used for food production from agriculture, forestry and aquaculture sectors (FAO 2014). Nepal though rich in water resources but has been largely left behind to use irrigation water for increasing food production. The crop, horticulture, pasture and aquaculture productivity remains poor comparing to global partners due to inadequate irrigational water supply infrastructures. As a result major food items such as rice, maize, meat, fish, fruits are imported (ADS 2015) including drinking water supply still remains an acute problem in the country (Merz et al 2003, Timilsina et al 2004).

One of the reasons why Nepal agriculture productivity is far below among the south Asian countries is due to insufficient fertilizer use (Rijal 2001, Shrestha 2010, Ghimire 2013). Nepal entirely depends on import of inorganic fertilizer (MoAD 2014). This was probably the reason why Nepal being an agrarian country never initiated to establish a fertilizer factory for fulfilling her potential demand of 700,000 mt of inorganic fertilizers (MoAD 2014). Actually it is known the fertilizer factory requires substantial amount of electrical energy (Swaminathan and Sukalac 2004, Gerlagh and van Dril 1999, Worrel et al 2000) which Nepal has yet to build the capacity. Thus, the hydropower and water has multiple uses and indispensable for all development and infrastructural works including the fertilizer plants, food security and curbing greenhouse gas emissions (Pandey et al 2014).

About two and half centuries before it was depicted that landlocked country remains deprivation of wealth (Smith 1776, Faye *et al.* 2004, Lahiri and Masjidi 2012). The facts still remains almost the same as human development report has shown the group of landlocked countries among the least developed ones (UNDP 2012, FAO 2014). It has rarely been realized and recognized how the degree and magnitude of mountainous landscape in landlocked countries exacerbate economy, poverty, deprivation, malnutrition, life span of people, human development index? Lack of territorial access to the sea, remoteness and isolation from world markets result in substantially higher transportation costs for land-linked countries and reduce their competitiveness in international trade (Kharel and Belbase, 2010), thus to human development index. Many poor mountainous countries including Nepal invests huge amounts of foreign currency in importing raw and processed agro commodities to feed their citizens.

Mountainous countries deprived of seashore had often been mostly weak in human development index (HDI) probably due to remoteness, insufficient suitable land for agriculture production, hardship for transportation, distance from sea port and high cost for road, railway and air traffic infrastructures (Smith 1796, ADS 2012, ADB 2013). However, countries having no sea boundaries have been offered leverages to use the route and ports of neighboring countries aligned with shorelines (UN 2009).



(A) (B)

Figure 1. Land-locked countries of the world (A), transverse view of land-linked mountain country Nepal (B).

Nepal is overwhelmingly a roughly rectangular mountainous country occupying approximately 83% of parts by hills and mountains, representing 9 out of 10 tallest mountains of the world including Mt. Everest, surrounded by India from three sides and China from rest (Figure 1). The high altitude and stiff snow covered mountain areas, where no agricultural practices and human settlement is possible serve the purpose of regional and global environmental services such as wildlife sanctuaries, pasture, biodiversity, water recharging areas playing substantial role on conservation of water sources, forestry, energy production and irrigation downside. Thus, the water, energy and food sectors have integral relationship, however, traditionally these sectors functions independently without caring to other crucial components, in general.

In connection with agriculture, food security, transportation, natural oil, the hydropower becomes more indispensable in absence of petroleum product (NRB 2007, Regmi 2008). For example Nepal do not have yet its own petroleum products, it has to absolutely depend on others. The landlocked country often faces the frequent blockades from neighbors (Faye et al 2004, Jha 2015). Recent blockade in year 2015 to Nepal severely affected business and marketing, thus suffered the economy of the country. Moreover, the agriculture sector heavily facing the problem of youth migration, womenization, urbanization, conversion of agricultural land to other purposes (Timilsina et al 2004, Tamang et al 2014, Paudel et al 2014) causing multiple times price hike of commodities and essentialities cautioning red alert unless new approaches are not adapted to balance food, water and energy demand.

In recent years it has been argued that water-energy-food nexus modal is more efficient economical and environmental developmental approach to address the ever bulging populous countries for sustainability (Bizikova et al 2013, Gurung 2014, FAO 2014). As a result some preliminary initiatives on water-energy-food nexus approach for overall policy change have been initiated (Pandey et al 2014, WEF 2014). Therefore, the purpose of the present work is to further elucidate the importance of water-energy and food nexus model for

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water, energy and food security in landlocked countries. To prepare this paper published data set on area, population, and Human Development Index (HDI) of landlocked countries were collected from various sources including United Nations websites. To show the interrelationship between the total area under mountains and HDI a simple linear regression curve was drawn. Similarly the relationship between the HDI and population of most landlocked countries (n=41) was examined using the linear regression curve.

Why Water-Energy-Food Linking Approach in Mountainous Landlocked Country?

According to Lahiri and Masjidi (2012) approximately 20% of the countries in the world are landlocked; they are distributed as approximately 40% of the world's low income economies and less than 10% in the world's high income countries. No country could survive without an outlet to the sea, thus, there are certain privileges being landlocked according to the UN charter (Sinjela 1982, UN 2009). However, the UN charter does not explain the privileges rational to the areas covered by gigantic snow covered nearly pristine mountains and hills of landlocked countries offers direct agriculture use but provide ecological services to the global communities. It would have been more rational if such privileges could be offered to a particular landlocked country based on how much land is arable and how much are nearly pristine providing ecological services. Therefore, it is argued that being a Himalayan country, Nepal's about 83% is covered with snowy hill and mountains as the home of the nine out of ten tallest mountains on the earth implying that most area of the country is unsuitable for the general agriculture. A major portion of nearly pristine Himalaya which are where agricultural cannot be performed but provides highly important ecological services of carbon sequestering, water recharge, storage, maintaining biodiversity of global significance (Nature 2009, Rasul et al 2011, ICIMOD 2012). If these arguments are correct, then Nepal should be liable to obtain more leverages than other landlocked countries being serving more ecological services to global communities. It has been correctly described by Rasul et al (2011) that despite the high contribution of the mountains, the mountainous countries are still marginalized in the development agenda. It is unlikely that such an argument could be convincing, in general. Therefore, instead of bargaining on the ground of ecological services it would be more substantial to utilize own natural resources, the water-energy-food linking approach for sustainable development of mountainous landlocked countries. This approach provides the opportunities to enhance efficient use of scanty natural resources. As a result the economy of the country could be more independent and productive paying more for people hard work to reduce the youth migration from agriculture, food security, improvise the livelihood and then the human development index.

To examine if there is any relationship between the HDI and population of the landlocked countries, a linear regression between 41 landlocked countries (Figure 2) showed that the HDI does not have substantial relationship with total size of the country and human population supporting the idea that HDI might show closer relationship with the areas used for agricultural purpose, productivity and areas covered by the mountains. This finding might supports the idea that human development index probably more closely associated with arable land, income gained through commercial agriculture products, domestic markets, physical infrastructure and remoteness from world markets etc. It is recommended that future studies should examine the relationship between pristine areas covered by mountainous land unusable for agriculture and HDI.

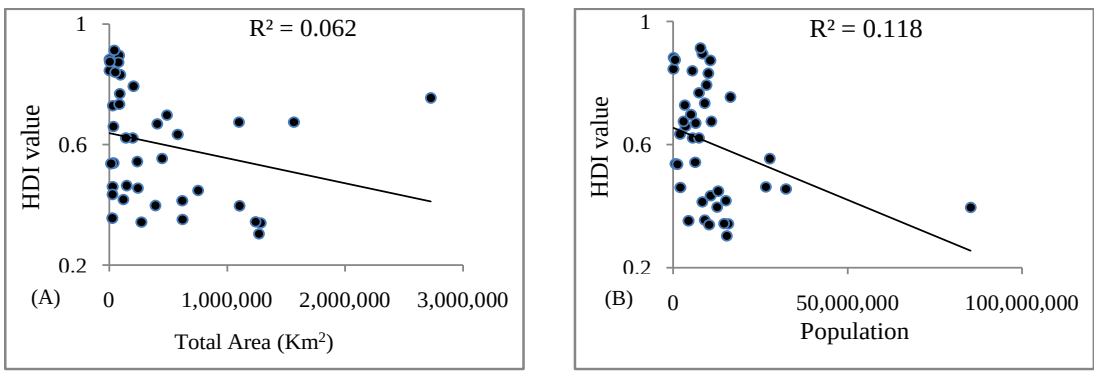

Figure 2. Interrelationship between Human Development Index and total area (A) and population (B) in most landlocked.

The Water-Energy-Food Model for Nepal

The model of the integrated approach of water-energy-food nexus for harnessing the advantages of vertical slopes through watershed-hydropower-irrigation-aquaculture-agriculture-integrated nexus is proposed (Figure 3). This integration approach is expected to decline the cost of infrastructure to great extent comparing to individual approach. The integration proposes that high mountains pristine areas should be preserved for watershed catchments areas so water could be abundantly accumulated for hydropower and irrigation purpose down (Rasul 2012). The hydro power of pico, micro, and mega scale tail waters should not be released as traditionally practiced (Figure 3A), instead earlier to release in streams back could be channeled to cold water aquaculture in mountainous regions (Figure 3B, 3C). The outlet waters from aquaculture ponds should use to irrigate agricultural lands for food production. This initiative links the part of the story that aquaculture is one of the fastest food industries of the world (De Silva 2001) enabling food production and water conservation to prevail social transformation among small holder led agricultural societies (Gurung et al 2011, Gurung 2012, 2014). The reasons of poor uncompetitive agriculture sector besides low suitable land, fragmentation, sloppy mountains unsuitable setup for agriculture, poor

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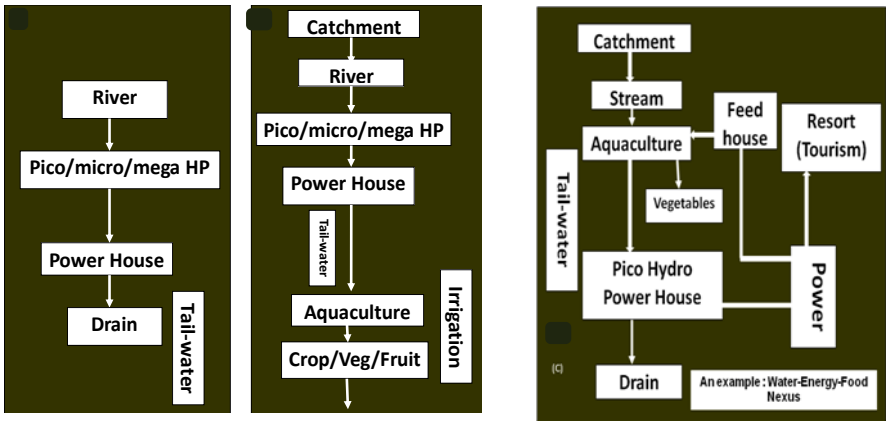
accessibility and transportation, high transportation cost, availability of quality fertilizers in right time and place area also the main (Shrestha 2010). Recently, policies of agriculture commercialization instead of promoting subsistence one seems to be adopted by governments because the commercialized agriculture might have several advantages, however, the commercialization of agriculture would require support from multiple sectors for which the current proposition has been justified.



(A) (B) (C)

Figure 3. Traditional (A), proposed model of water-energy-food integration (B), and an example of water-energy-food nexus (after Gurung 2014).

WAY FORWARD AND CONCLUSION

Generally, food, water, and energy security is a common challenge for the countries of South Asia (ICIMOD 2012), however considering the HDI, it is the landlocked country Nepal ranking poorest among all, majorly due to the lack of shoreline of its own for transport services to people living in hills and mountains besides many other issues. There are several examples where the water-energy-food nexus have shown comparatively better productivity and economy in terms of agricultural food production, energy and irrigational uses (ICIMOD 2012). Such facts are required to be implemented for efficient natural resource use in the country by government, non-government and private agencies through actions, so that could be reflected in terms of rapid economic growth and improving human developing index in Nepal.

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