Guidance note[1]: Agricultural typologies for Somalia

Improved understanding on designing spatially differentiated strategies: Typologies of territories based on poverty, agricultural potential, and efficiency to target investments and interventions in the framework of the Hand-in-Hand Initiative

Abstract

Agricultural development depends on identifying and investing on opportunities which increase productivity, competitiveness and bring economic growth, but also create employment, increase incomes, and alleviate poverty. In addition, in cases where opportunities are just not present, policies need to provide alternative solutions and deploy interventions that bring inclusive social development. Finding these opportunities depends on interactions of many actors that take place in a complex physical and socioeconomic environment.

Considering and accommodating for the physical and economic dimensions of the environment in which farmers and the poor in agriculture and food systems operate, requires an approach that combines economic, statistical, and spatial data and analysis. The approach needs to consider, in any environment, the capacities of farmers to efficiently generate profit from their farms in the markets they sell their produce.

The present note describes such a tool using GIS and socioeconomic data analysis. The output of the tool is a standard classification of territories in a country which integrates agriculture and food systems potential in relation with farmers' efficiency to generate profit in locations where poverty is pervasive. This classification, or typology, serves thereafter as a broad guide for investments and policy interventions.

Ultimately the guide contributes to the efforts of the Hand in Hand initiative, the flagship FAO corporate programme launched in 2020. The HiH initiative's key objective is to contribute in making progress in SDG1 and SDG2 targets by informing governments, donors and investors on opportunities that bring inclusive agriculture and social development through an evidence-based territorial development approach.

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Content

1. Background

When deciding to invest resources in agrifood systems or implement social policy interventions, governments, development partners and private actors, are confronted with difficult decisions. Difficulties emerge from the need to prioritize across alternative options in terms of their returns like profits, incomes, production, productivity, and poverty and hunger reduction. Reality and plenty of research suggest that not all interventions are equal and benefits per dollar spent in different sectors or subsectors and locations vary widely (see Mogues et al. 2012 for a summary).

Returns to investments and other policies are not the same across space since local conditions, available infrastructure (transportation, energy or other), climate, land, soil and water characteristics make some options dominate over others in different territories. When social objectives in terms of poverty or hunger alleviation are key driving forces for policy and investment decisions, targeting areas that host most of poverty and hunger, needs to be integrated in the policy analysis.

These types of challenges are similar for all stakeholders engaging in agrifood systems. Economic performance, social inclusion, but also environmental objectives, may carry different weights across types of stakeholders depending on what is their priority.

Intergovernmental and international development cooperation agencies may give higher priority to social returns and improvements in the livelihoods of the poor. On the other hand, private sector companies engaging in the sector assign different weights when they are to decide among multiple options relating with where and how to invest. Finally, the physical environment and local agroecological characteristics, naturally condition the options and possibilities for policy and investments in any territory.

2. Objectives and output

Identifying opportunities that succeed accommodating diverse incentives and multiple objectives, social and economic but also environmental, would be ideal in the challenging situations that developing regions are facing. For inclusive agricultural development, drivers of investment and resource allocation decisions need to consider local conditions and be based on the best possible outcomes. These outcomes refer to improved agricultural production and productivity, profits and competitiveness while reducing poverty, hunger and malnutrition and promote inclusiveness for vulnerable groups of the population.

The present note describes an analytical tool that in broad terms can guide investment decisions and policy interventions in agriculture and food systems. The tool's objective is to inform about options and priority areas in any given country, where policies and investments can enhance economic performance and at the same time improve the livelihoods of poor people dependent in the agrifood systems. At the same time, they need to

consider and respect the local physical environment and natural resources. Such interventions bring improvements in the livelihoods of producers, casual workers and many actors engaging in agrifood systems. By improving efficiency in the system, net food consumers are able to benefit too from lower food prices and more diverse diets.

The output of the tool is a standard classification, or a typology of territories in a country. The typology integrates information on agriculture and food systems' potential with farmers' efficiency to generate incomes, revenues or profit in locations that poverty is pervasive. To succeed in this effort, the typologies classify territories by their agricultural potential and farmers capacities to make profits in conjunction with the level of poverty.

Box 1: The Hand in Hand initiative

The Hand in Hand initiative is an evidence-based, country-led and country-owned initiative launched by FAO with the aim to contribute at eliminating extreme poverty (SDG1) hunger and all forms of malnutrition (SDG2) by accelerating agricultural and food systems transformation and promoting sustainable rural development.

The HiH framework is a tool targeting the poorest (SDG1) and those with higher rates of hunger and malnutrition (SDG2) through spatially differentiated strategies while all dimensions of food and agriculture systems are brought together. The initiative maps donor interventions in order to identify partnering opportunities. The initiative utilizes GIS data in order to overlay multiple information layers to prioritize interventions.

The initiative adopts a market-oriented food systems approach to increase the quantity, quality, diversity, and accessibility of nutritious foods available in local, regional and national food markets and to improve food system capacities to deliver nutrition and healthy diets for everyone.

The initiative focuses on well-recognized, but under-supported potential areas of agriculture and agri-food value chains to lift large numbers of the rural poor out of poverty through integrated approaches by achieving greater collaboration and partnership between the UN agencies, development partners, private sectors including civil society organizations.

The initiative focuses not only on increasing producer productivity but more importantly, on improving realized incomes in the short run along with sustainability for the longer-term. Besides, the initiative promotes the sustainable use of biodiversity, natural resources, and ecosystem services, and supports climate change adaptation, mitigation, and resilience.

The initiative provides data and analysis to evaluate interactions and trade-offs among objectives and actions, helping to pinpoint key bottlenecks and focus policy dialogue, and the key configurations needed in terms of local partnerships. This is in line with the UN's priority commitment to "leave no one behind" and Somalia has been selected as one of the pilot countries to roll out the HiH initiative.

This classification aims at serving as a broad guide for setting spatially differentiated policies, programs and investments. It does that by informing governments, donors, development agencies, large scale private investors, the civil society but also the farmers

themselves where to target investments and/or social policy interventions that improve efficiency, generate profits and incomes and increase competitiveness.

The guide is a crucial component of the framework guiding the flagship FAO corporate programme of the Hand in Hand initiative. The HiH initiative's ultimate objective is to contribute to making progress in achieving SDG1 and SDG2 targets by promoting inclusive agriculture and social development through an evidence-based territorial development approach. The results from the analysis of the typologies, inform governments, investors and donors about priority areas and opportunities that bring benefits to all.

The next sections describe the steps of the analytical methodology that generate these key layers. Finally, an example is used to indicate how the different data and layers of information are analysed and brought together to create the typologies in a country.

3. Conceptual framework

The tool integrates information layers that are clustered together to generate a classification of typologies of territories as mentioned already. These layers integrate local physical conditions and infrastructure and at the same time approximate socioeconomic aspects about farmers and agrifood system's economic potential and poverty status. They thus create a comprehensive and informative context to base investment and policy decisions across space and territories for the HiH initiative.

a. Biophysical and agroecological conditions and other information

In first information on specific agroecological and biophysical conditions is integrated in the analysis. This refers to key data that characterize agriculture as predominantly land, water and climate dependent sector in developing countries. In many cases in the past, agroecological zones (AEZs) (FAO, 1978; Fischer et al., 2002), land cover and land use (Anderson et al., 1976, Loveland et al., 2000) supported prioritizing investments in agrifood systems. This information points at the heterogeneity of the biophysical and agroecological dimensions that condition the performance of farmers and agriculture and food system activities.

From this perspective the analysis behind the typologies tool accommodates environmental sustainability aspects. This because in territories that the physical environment does not allow, the regions are identified of low potential for intensive agricultural development. In addition, information on the state of specific natural resources like water, carbon emissions and other, is integrated depending on the context.

Typically, spatial information used in the preparation of the typologies refers to the Normalized Difference Vegetation Index, rainfall patterns, types of land cover and travel time to the nearest market (usually a city). The information is sourced at the FAO-GIS platform or

other sources assessed as more accurate by the analyst. The data are aggregated at the lowest available administrative unit in a country, and they feed into the analysis to indicate how conducive is the physical environment to agriculture and farming. Example of map with biophysical information is presented in Figure 1.

Additional information is integrated as needed to reflect specific country contexts as well as entry points that Hand in Hand programmes are leveraging during country operations. This can be information on water availability and efficiency of use, soil types and quality, electricity and energy availability, access to financial services, access to internet and broadband signal, livestock density, production, productivity and yield gaps by crop or groups of crops and many other.

Access to available infrastructure in terms of primary and secondary roads, ports and transportation hubs is used as an extra layer in order to inform about the travel time needed to connect supply with demand areas (Figure 2). This information supports estimates of transportation costs that need to be integrated in relevant investment and business plans.

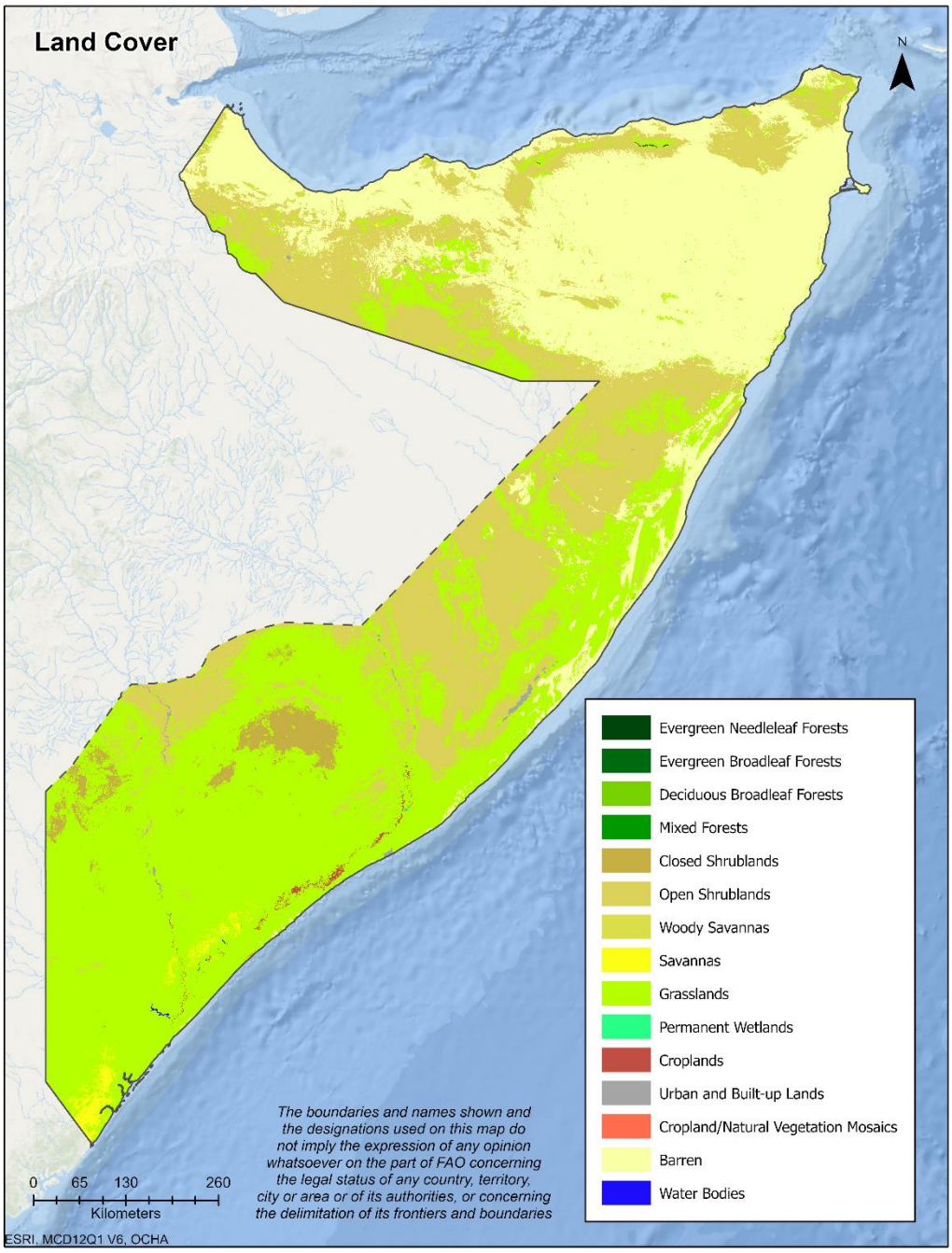
Box 2: The HiH GIS platform

The GIS platform that FAO launched as part of the HiH initiative contains millions of information layers on crops and vegetation, land, soil water and many more. Climate but also other information incorporated in the platform provide real time data on current conditions that allow interventions responding to emergencies.

The platform includes and continuously adds extensive, reliable, detailed, historical as well as contemporaneous, state of the art information and data including from satellite imagery. This improves understanding on gaps and challenges in agrifood systems and allows assessing the feasibility and potential to undertake development projects and investments to provide solutions and fill such gaps.

For example, analysis of the data, contributes to building the evidence base in order to identify if soil types and water availability in a territory are adequate to invest and develop specific commodity value chains. Incorporating additional information layers like electricity availability, transportation and internet connectivity and others, indicates possible locations to install processing or cold storage units that can be integrated with electronic commerce platforms. Data on transportation infrastructure provide extensive information on challenges and opportunities to link rural agricultural areas with markets locally but also internationally.

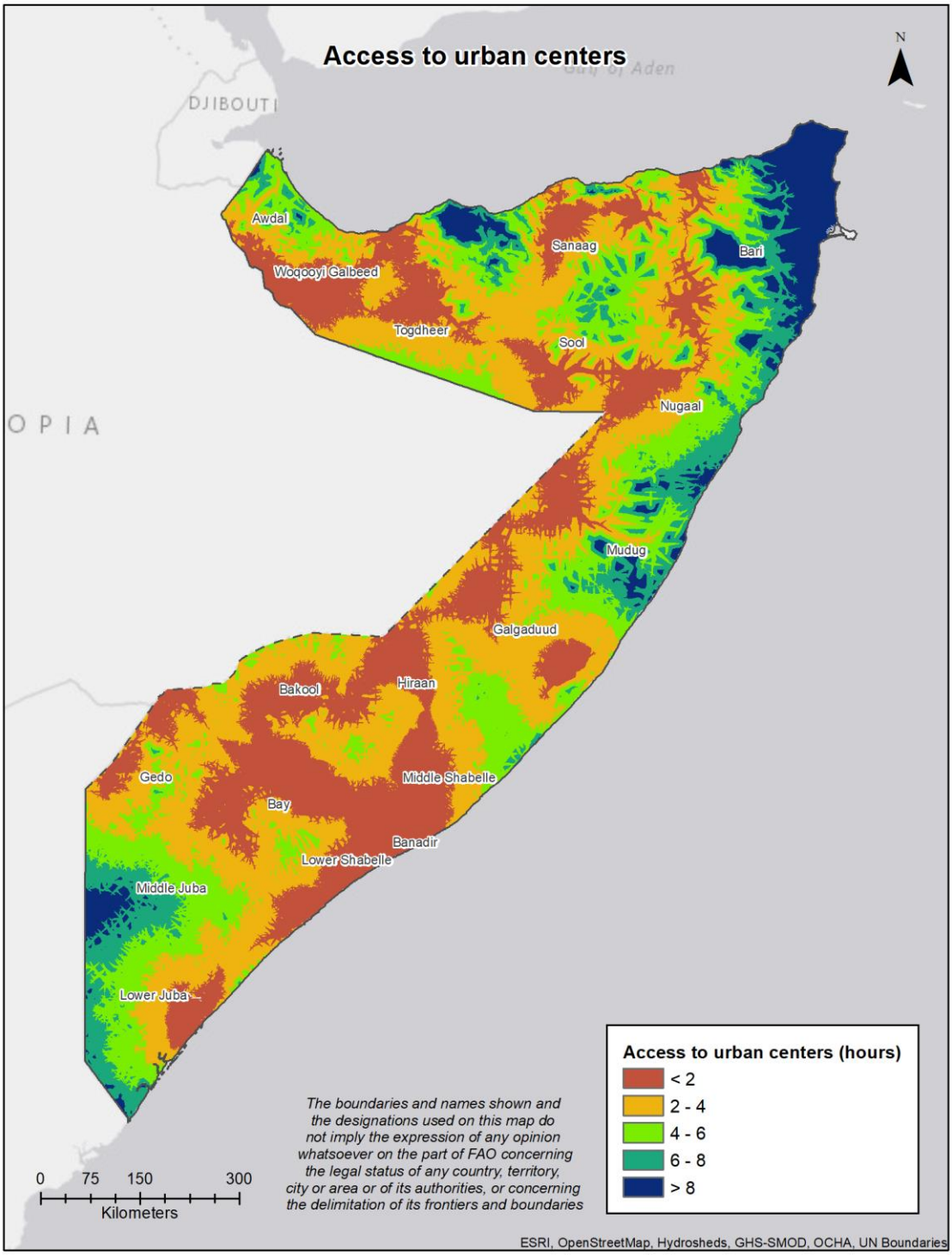
Figure 1: Land cover map[2]



Source: FAO-HiH GIS team (2020)

[2] The boundaries and names shown and the designations used on these map(s) do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Figure 2: Accessibility map



Source: FAO-HiH GIS team (2021)

b. Agricultural potential and efficiency

The tool integrates outputs from analysis that supports identifying gaps and opportunities emerging from access to markets and the potential for farmers and the sector to generate efficiency gains and increase incomes by enjoying higher profits from selling their produce. Realizing these efficiency gains, translates into higher output and productivity which allows also net food consumers accessing food at affordable prices.

The information layer aims to indicate where but also how alleviating constraints, and possibilities to increase competitiveness can be strengthened, by taking advantage of market opportunities which exist but are not exploited at their full potential. It does that by using and analysing information on farmers' livelihoods coming from household or agriculture census data including from GIS as described above.

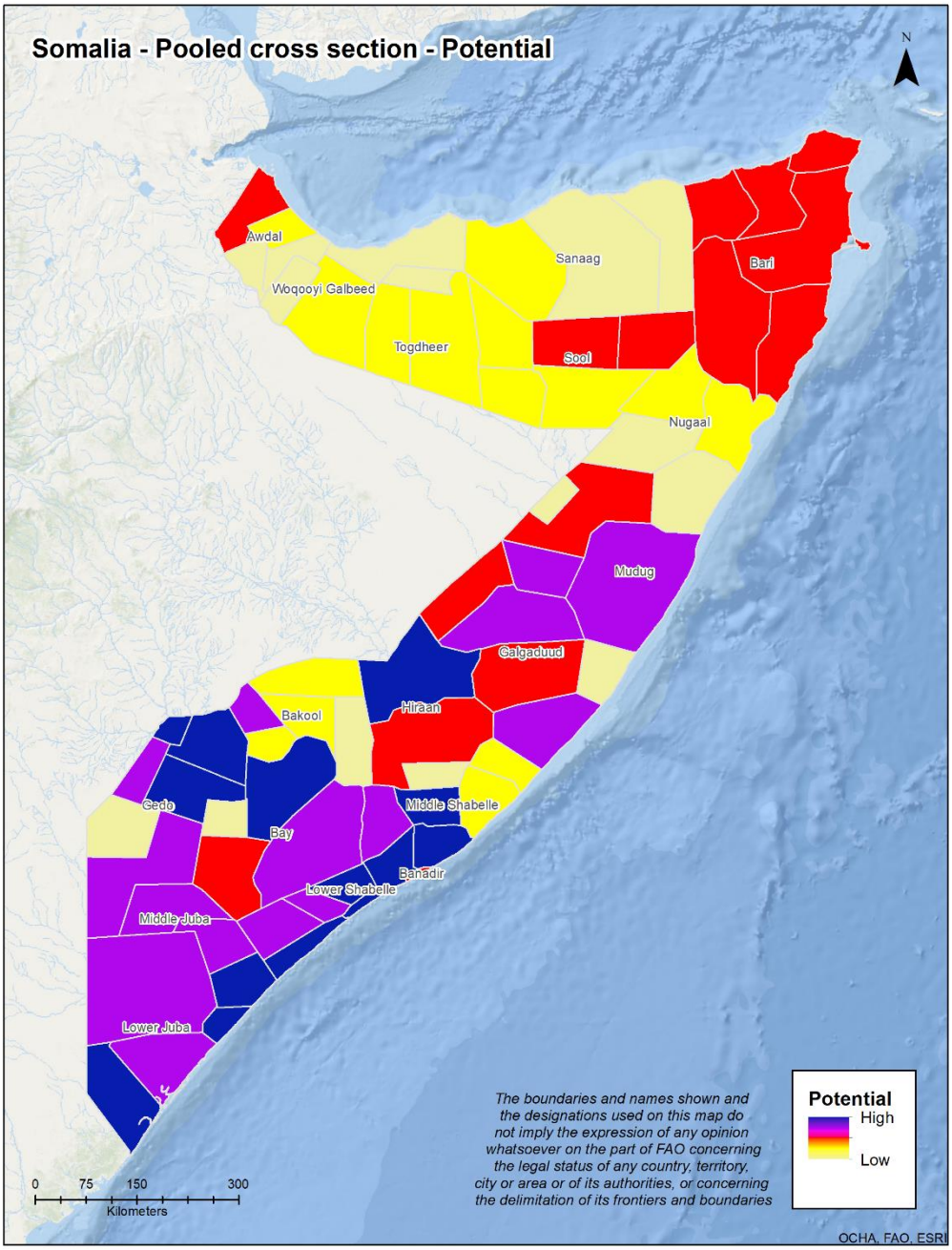
The analysis uses information and data from surveys and censuses, recording farm practices, inputs and output prices and earnings for pastoralist, crop producers and mixed farming systems in all corners of a country. The analysis identifies those that make the most in terms of revenues or profits in view of the market conditions and prices they face and the agroecological context in which they operate. The best producers are those with the highest revenues or profits given the input or sales prices they face, and they set the benchmark under which all others are ranked below.

This part of the analysis provides valuable information that contributes to building the typologies of territories. In first the distance from the benchmark farmers, defines the size of the unexploited potential in terms of revenues or profits for each farmer. This potential for a number of reasons and constraints is not materialized. The benchmark is also called the frontier in terms of maximum profits or revenues that all things considered is available for grasp.

The distance to the benchmark defines the available **agricultural potential** in broad terms for each farmer (Figure 3). The analysis on the preparation of typologies aims at identifying and measuring this potential across space in all countries the HiH initiative operates. Summing up the distance across farmers in a territory, results in the agricultural potential that is available but unexploited. Investments or other policies aim at alleviating the constraints that are responsible for this potential left unexploited or not realized.

Farmers are not the same with each other even when operating on similar plots of land or when facing similar agroecological conditions within a region, or when they face similar market conditions. They perform the same activities in different ways in view of their knowledge, skills, experiences and other available resources and assets. Moreover, most of them are small in size and scale in their operations, which means that in the markets they participate to purchase inputs or sell their produce usually face given prices that they cannot easily negotiate.

Figure 3: Agricultural potential

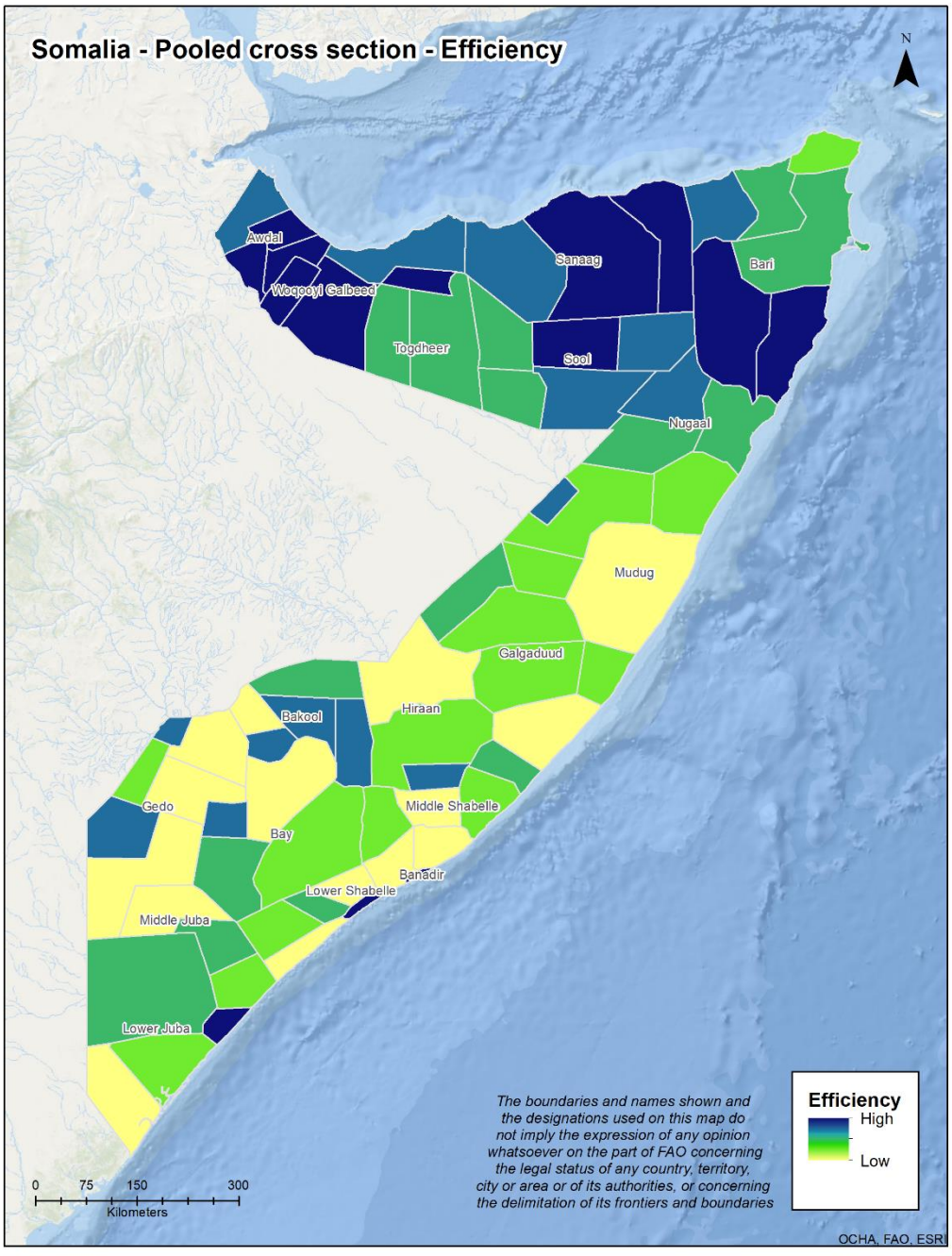


Source: Stochastic frontier analysis FAO-HiH task force (2024)

Still however, some of the farmers are more efficient than others in taking advantage of market prices whether by choosing the right time to buy or sell, or by using less inputs for a given level of output or by producing more for a given level of inputs relative to their peers. In cases their entrepreneurial spirit and business orientation makes the difference.

A measure of efficiency indicating this diversity in the skill of farmers to take advantage of market opportunities and enjoy higher profits and revenues or lower costs, is estimated through the analysis. This **efficiency score** measures the extent to which farmers are able to exploit market opportunities while considering their heterogeneity in skills and capacities in the context they operate (Figure 4).

Figure 4: Agricultural efficiency map



Source: Stochastic frontier analysis FAO-HiH task force (2024)

c. Poverty maps

Finally, the tool employs data that map poverty across space in order to weigh in, objectives that will support identifying opportunities or other policy options that will lift people out of the state of poverty. Poverty maps are frequently used to guide and target investments and development policies since they provide a method to locate the poor (Lanjouw, 1998; Hentschel et al., 2000; Elbers et al., 2001; Deichmann, 1999).

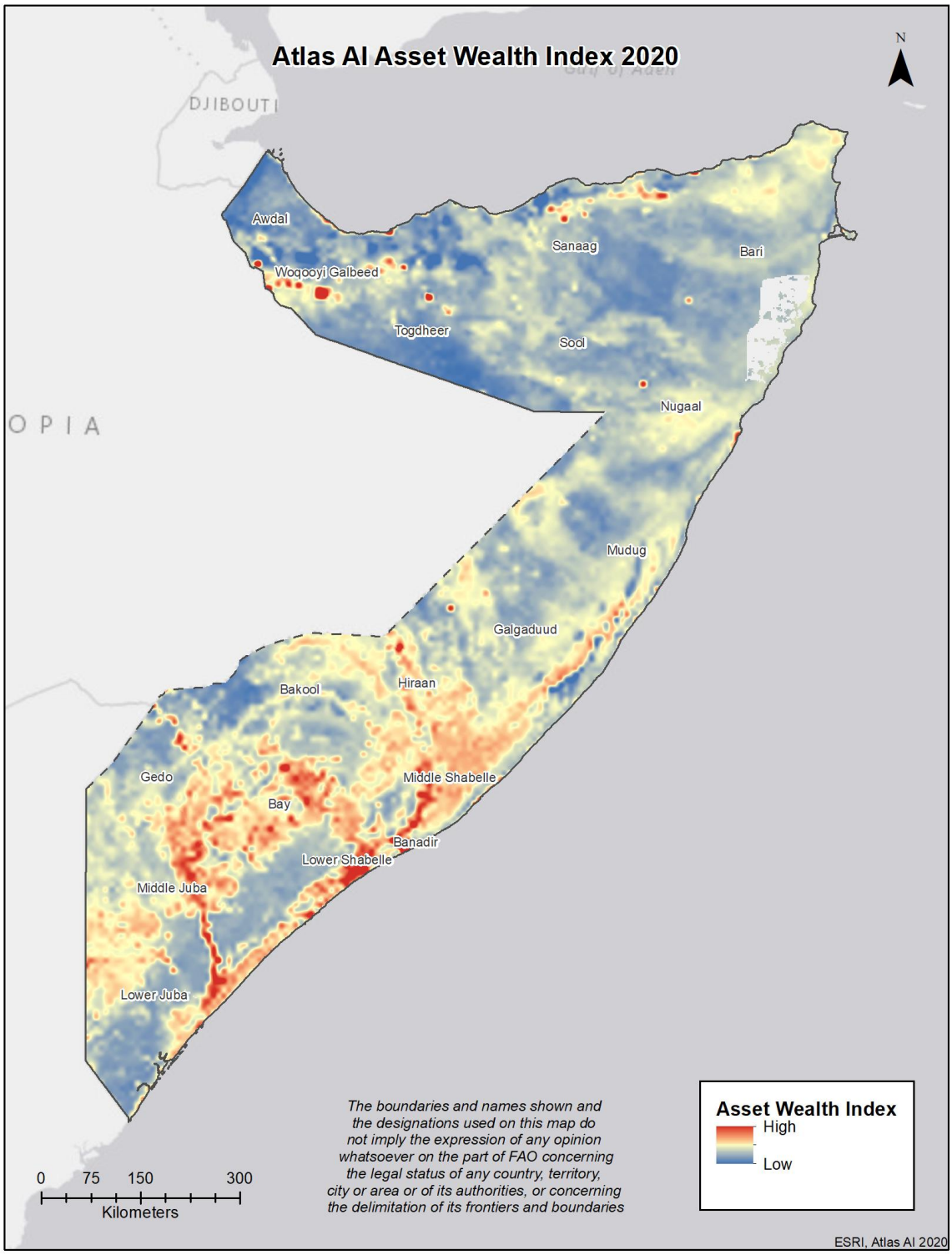
This layer integrates information that supports efforts to make progress in the key objective of the HiH initiative; that is contributing in eradicating extreme poverty which is measured through SDG 1. The poverty map is presented on Figure 5.

Data that map food insecurity in terms of hunger and malnutrition are to be integrated in order to identify territories and improve targeting for interventions food insecure groups. In this way the HiH initiative contributes to making progress in eradicating hunger and malnutrition which is measured through SDG 2.

In addition, and depending on the context in countries under emergencies, crisis or conflict, maps on the severity of hunger and malnutrition are integrated to identify priority regions and territories for interventions. Relevant information from the Integrated Phase Classification (IPC) mapping tool, rapid vulnerability assessments, but also non-conventional sources of information are employed to fill the data gaps. Moreover, other tools based on text mining and artificial intelligence are employed to provide the necessary evidence that will support identifying territories where urgent attention is needed.

Especially in country cases where data scarcity is a critical challenge other layers of information can be integrated in order to identify extreme poverty and food insecurity hotspots. Relevant information from the Integrated Phase Classification (IPC) mapping tool is overlayed with population density, availability, and access to infrastructure (transportation, electricity, communications etc.), is utilized to approximate as close and feasible the welfare situation of the populations across regions and territories. In these cases, welfare (in contrast to poverty maps) maps are developed on a case by case basis.

Figure 5: Poverty map



Source: ATLAS-AI (2020)

4. Typologies of territories

The conceptual framework guiding the tool developed by Maruyama et al. (2018), integrates the layers of information described earlier into a single map that identifies different types of territories considering poverty, agricultural potential, and efficiency. Based on these three key layers, the **typologies** provide informative but only broad indications to policymakers in order to focus geographically, decide across types of interventions, prioritize policies, and allocate resources and implement investments in a spatially differentiated way.

At its core, the idea is that different regions should not only be given different degrees of priority, but that the type of policies and investment should be tailored to the physical and socioeconomic dimensions and the needs of each specific region and territory.

In order to do this, the framework puts forward the idea of constructing the **typologies** of territories and regions in a country based on the three key layers presented earlier. The layers reflect:

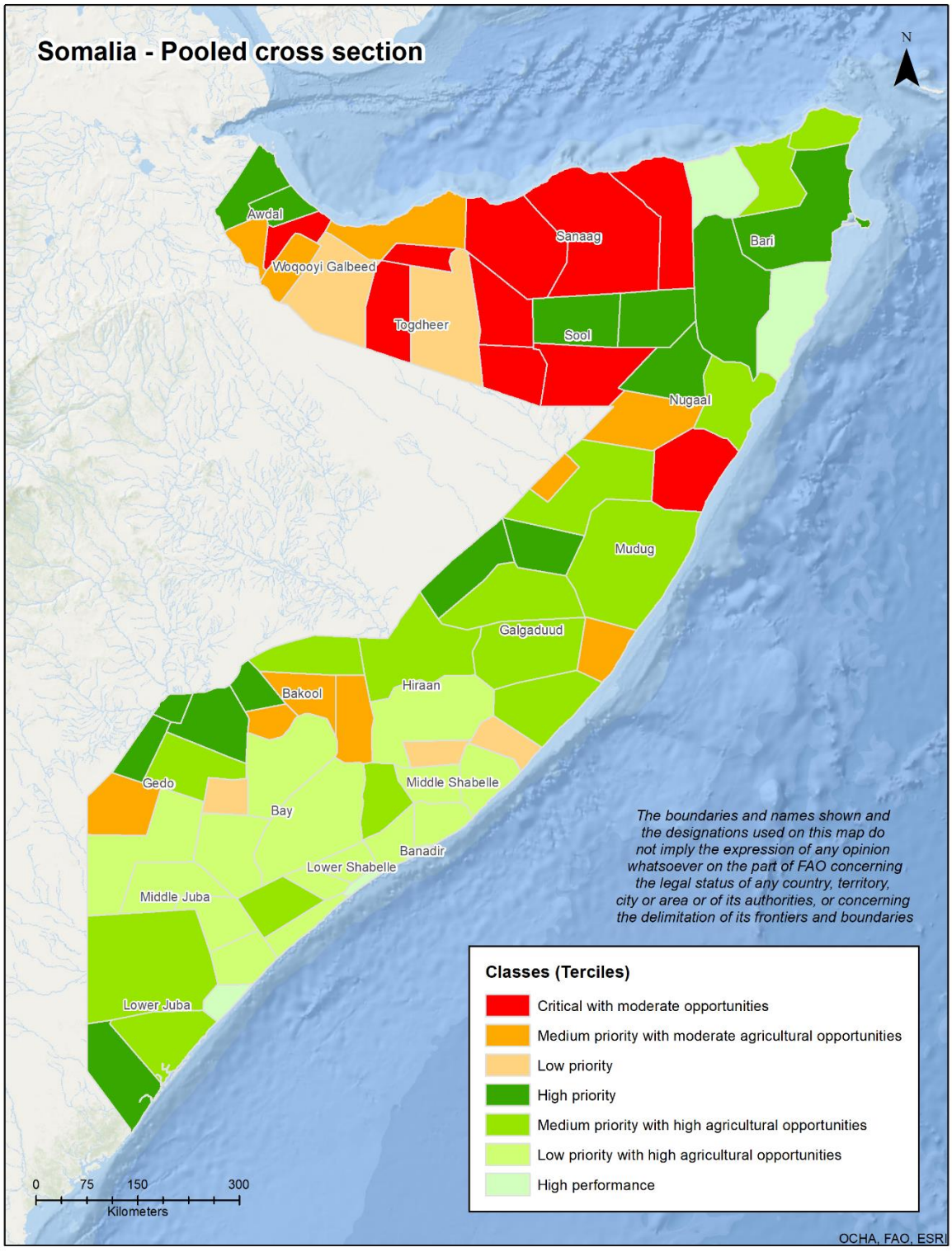
1. The urgency of intervening as approximated by the poverty, hunger and/or malnutrition (and/or their severity) maps.
2. The agricultural potential of the territories in terms of possibilities to leverage unexploited revenues or profits.
3. The efficiency of farmers and producers to make the best in terms of revenues or profits given the market conditions they face but also their practices, skills, knowledge, and experiences in farming and engaging with markets.

The output of this overlaying exercise is presented in Figure 6. Figure 7 provides guidance on how the different colours of the map are interpreted.

Intuitively, the conceptual framework relies on the assumption that regions with medium to high agricultural potential and characterized by high poverty should be prioritized for agricultural interventions. On the other hand, in regions with moderate agricultural potential and/or moderate levels of poverty, agricultural investments are not necessarily and absolute less urgent and it may be best to target these regions with investment in other sectors.

The following section elaborates on the possible or candidate policy bundles that are to be considered in supporting the design and development of HiH supported programmes in different regions and territories.

Figure 6: Agricultural Typologies



Source: Stochastic frontier analysis FAO-HiH task force (2024)

Figure 7: List of typologies

	Poverty	Potential	Efficiency
Critical with moderate agricultural opportunities	High	Moderate	Any
Medium priority with moderate agricultural opportunities	Medium	Moderate	Any
Low priority	Moderate	Moderate	Any
High priority	High	Medium / High	Medium / Moderate
Medium priority with high agricultural opportunities	Medium	Medium / High	Medium / Moderate
Low priority with high agricultural opportunities	Moderate	Medium / High	Medium / Moderate
High performance	Moderate	Medium / High	High

Source: Maruyama et al. (2018)

5. Linking the typologies to the design HiH programme supported interventions

The typology of regions and territories indicate bundles of policy interventions to consider and support the design of Hand in Hand supported programmes. Different policy bundles are to be suggested depending on the typology classification, and aim to address needs and challenges facing each region or territory.

Before moving into the description of the suggested policy bundles, a number of points are made to facilitate interpretation.

In first, regions and territories that concentrate poverty, hunger and malnutrition and display high inequality and exclusion for vulnerable population groups, remain the key target locations for Hand in Hand programmes.

Secondly, all regions and territories within the country are of priority. The typologies indicate policies to consider that will support:

i) Exploiting agricultural potential if it is not fully exploited;
ii) Enhancing further or expand the potential even if it is currently fully exploited with interventions that will bring additional value added;
iii) Creating potential in regions or territories where current agroecological or other conditions may indicate that there no potential;

iv) Applying policy bundles that address emergencies or critical conditions in regions in crises or conflict.

Finally, complementary assessment using national and local expertise is necessary in order to validate and contextualize the resulting typologies. Despite the fact that the most advanced and sophisticated techniques and data are used to develop the typologies, the need to cross-reference with expertise at country and local levels is indispensable to complement and guide the design of programmes, policies, projects, interventions and investments. In this aspect focus group discussions with national experts, government officials, key players in the agriculture and food systems and the value chains, regional and local experts and authorities, including field missions have to be integrated in the effort to identify interventions and policies.

After the above points, we continue with a more elaborate presentation of suggested policy bundles by typology of regions or territories. In the approach, interventions in regions and territories are broadly classified as follows:

1) Interventions for areas with moderate agricultural opportunities;
2) Interventions on areas of high agricultural opportunities; and
3) Interventions on high performance areas.

Below each set of interventions is described further. Along with examples of how interventions could be adjusted to reflect and consider prevailing conditions in each territory in terms of poverty agricultural potential and efficiency. For a general summary please refer to Figure 8.

It is important to note that just as the maps presented in the previous section, the different policy bundles described in this one are for guidance only. They should be corroborated, validated, enhance, adapted, and tailored to the country's context at subnational level.

a. Interventions for areas with moderate agricultural opportunities

The set of interventions in areas with moderate agricultural opportunities should be differentiated between short-term and long-term investments. Short-term interventions must be prioritized where poverty levels are high but agricultural potential is moderate. Long-term ones must be considered for all areas with moderate potential regardless of their poverty and efficiency levels.

The purpose of the short-term interventions is to alleviate poverty not necessarily relying on agricultural-based policies. Instead, investments must be focused on protecting the poorest of the poorest covering the areas that had been proven to be more effective: social assistance, labour market, and social insurance.

For social assistance, conditional or unconditional cash transfers have proven to alleviate poverty and vulnerability in the short-term very effectively by raising and smoothing incomes. Also, social pensions provided by the state can help to reduce vulnerability of the elderly. In addition, economic and livelihood asset transfers known as in-kind transfers to

households facilitate income generation. Also, they can support nutrition with programs such as school feeding. Finally, public work programs that provide jobs in infrastructure in exchange of cash or food are effective in generating income.

Active and passive labour market interventions are also valuable tools to alleviate poverty in the short-term. Active interventions such as job centres, specific training and policies aimed at the unemployed and most vulnerable, can facilitate and incentivize them to find jobs and generate skills different from agriculture. Passive interventions are aimed to workers and employers. They include changes in labour legislation, maternity benefits, injury compensation, and sickness benefits.

Finally, social insurance includes formal insurance schemes, such as contributory pensions, health, unemployment or disaster insurance, and funeral assistance.

As mentioned earlier, regardless of their technical efficiency and poverty levels, areas with lower levels of potential require investments to increase their agricultural opportunities in the medium and long-term. This is particularly important as Hand in Hand countries are characterized by having a significant agricultural sector, with large portions of the population living in rural areas and being employed in agricultural activities. Therefore, investing in agriculture is a valuable opportunity for increasing returns in the agricultural sector in the long term.

Public spending on agricultural research and development (R&D) has proven to generate high rates of return in developing and developed countries. Recent studies suggest that per USD 1 invested in agricultural R&D, society gains approximately USD 10 in benefits (Alston et al., 2020). Not only R&D have improved factor productivity by increasing yields, but with the climatic challenges ahead, R&D must focus on easing the challenges of climate change. Therefore, R&D in agriculture becomes crucial to increase the agricultural opportunities of regions inside the country. Also, it is important to consider that investments in R&D payoff in the long-term. Accounting for results may take a significant period of time, therefore investments in this area should be steady and sustained (Alston et al., 2020).

Agriculture R&D involves a set of broad and numerous interventions, activities, and innovations. Specific interventions that can be considered for areas with limited agricultural potential can be (but not limited to): developing hybrid and inbred seeds with improved yield potential and higher drought resistance, biofortifying crops to improve vitamin and mineral deficiencies in the population, breeding programs and distribution, adoption of natural resource management and climate smart agriculture, improving water-use efficiency, promoting genetic resource management, improving market information systems, development of animal vaccines, environmentally beneficial cattle, among others (Von Braun et al., 2008).

Finally, investments in infrastructure are crucial to increase agricultural potential. Inadequate infrastructure can significantly hinder productivity and development of the rural sector. While different types of infrastructure support development of the rural sector, such

as electricity and roads, the scope of the program focuses on the creation of irrigation infrastructure. Developing irrigation at a small scale is key to generate improvements and increase potential in the medium-term.

b. interventions on areas of high agricultural opportunities

Conversely, the areas where the agricultural potential is medium-to-high, but efficiency levels (i.e. how close to your potential you are) are low, should be targeted with more specific agricultural interventions in order to allow these regions to reach their full potential. There are different policy interventions that could allow agricultural transformation in the short and the long-term: efficient supply chains, sustainability standard and practices, and innovation and technology.

Efficient supply chain policies are targeted to include rural and small households into the supply chain with commercial smallholders, and SMEs. Also, policies can be targeted on improving the supply chains by enhancing efficiency of processing, storage, transportation, and logistics of food, with a special emphasis on reducing food loss. Finally, improving existing policies can reduce distortion and increase incentives for private sector participation.

For sustainability standards and practices, climate smart agriculture practices can increase productivity, ease the pressure on natural resources, adapt and build resilience to climate change, and reduce greenhouse emissions. In addition, implementing global standards can ensure efficient use of land, water, and labour.

Innovation and technology rely on the same principles as the ones discussed in the lower potential regions regarding R&D development. As mentioned, innovations and technology not only increase productivity, but they are becoming crucial to face the challenges all regions will face due to climate change. In this case, innovation and technology can help in improving traceability, disease control, and nutrition. Also, innovations in business and financial models will help provide better services not only to farmers and smallholders but to all value chain actors.

c. High performance areas

Finally, in those regions that are already doing well (compared to the other regions inside the country), the focus should be on policies that promote higher-value products and ensure higher prices to farmers for their output. This includes orientation to international markets for export increase, certifications and organic production for higher premiums, and financial inclusion. This last one should be focused on providing return on profits savings, access to credit to expand access to inputs, land, and non-farm related businesses.

In addition, the high-performance areas represent cases to evaluate, learn and if possible, replicate in other regions and even countries. Therefore, evaluating the best practices of these regions becomes a priority in the public agenda. First it is essential to identify the contributions agriculture has made to reduce poverty. It can be done by designing and

implementing impact evaluations and assessments to gather rigorous evidence. Then processes and implementation of successful practices should be documented along with bottlenecks and points for improvement. Finally, the learning process must be a valuable resource that enables south-south cooperation. The development of a web-based knowledge platform for within country and south-south learning, as well as an e-learning centre to share best practices can be considered.

Figure 8: Typologies and example interventions

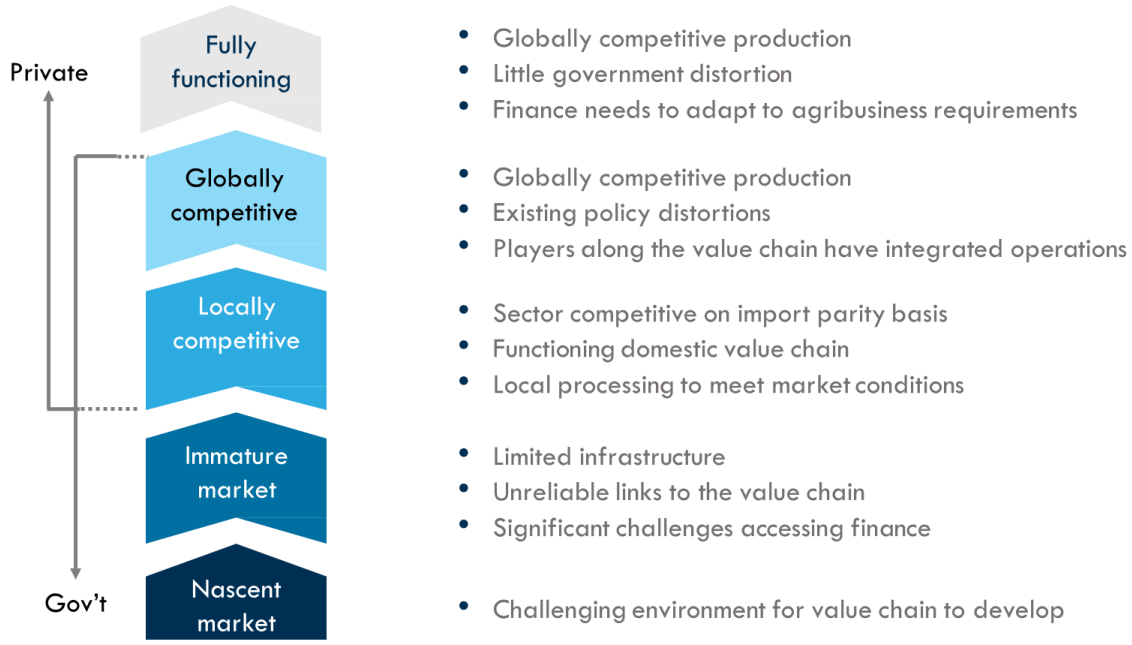
Typology class	Description	Examples of recommended innovations
Critical	High poverty, moderate potential	Long-term investments in agriculture such as funding R&D activities to generate technological changes and major investments in infrastructure. Short-term assistance programs such as conditional cash transfers that incentivize human capital investments are recommended.
High priority	High poverty, medium/high potential, medium/moderate efficiency	Reduction in market access costs through road improvements and price information systems (ICTs). Innovations that allow for improved access to inputs and extension services. Innovative inclusive financial instruments to allow for savings of harvest income towards investments in next season's production, credit for working capital, and insurance to mitigate risk of adopting new technologies Strengthening of horizontal and vertical integration institutions that provide better access to markets to smallholders such as farmer groups and contract farming arrangements Medium and small-scale productive infrastructure investments such as mini-irrigation projects and land management projects.
Medium priority with high agricultural opportunities	Medium poverty, medium/high potential, medium/moderate efficiency	
Low priority with high agricultural opportunities	Moderate poverty, medium/high potential, medium/moderate efficiency	
High performance	Moderate poverty, medium/high potential, high efficiency	Orientation to high values and export markets. Certification and organic production to obtain higher premiums from agricultural production. Increased financial inclusion to allow for higher returns on profit savings, credit to purchase additional land and expand farm and non-farm businesses.

Source: Maruyama et al. (2018)

Finally, the suggested interventions mentioned above can be implemented by private actors, as well as public ones. A continuous collaboration between both parts is illustrated along the continuous market model shown in Figure 9. This is a useful guide to identify which type of interventions (public or private) are more appropriate, depending on the stage of national and subnational markets. As stages of market development are identified before the interventions are designed, public interventions should be aimed at markets with challenging conditions for value chain development. On the contrary, once markets and value

chains are more competitive, the private support is crucial for its expansion and full development.

Figure 9. Market segmentation model for identifying interventions



Stochastic frontier analysis FAO-HiH task force (2021)

6. Recommended suitable locations for storage or processing units[3]

Identifying where supply links with demand along the length of food supply chains indicates where interventions and investments can support agricultural transformation and rural development while bringing income growth and contributing to poverty alleviation.

In every country, links of actors in food systems with national but also intra- and inter-regional markets, are identified through the input side (seasonal hired labour and purchases of fertilizers, seeds and other chemical inputs) and in the output side (trade, processing, storage and distribution of food, crops, livestock and dairy products).

This section documents a raster-based Geographical Information Systems - Multicriteria Decision Analysis (GIS-MCDA) proposal, for the calculation of optimal scores (Ribeiro 2021a,b,c) that support the identification of recommended locations for storage (warehouses, mobile warehouses or cold storage), or processing units (agro-industries).

The proposed modelling variables/criteria are the main transportation network infrastructure, human population density and production (livestock, crops or groups of crops varying by country). A raster-based travel time cost analysis was developed using

[3] Section based on Ribeiro (2021a,b,c)

transportation infrastructure data and relevant services like access to financial services (bank locations) or access to IT (internet access) are also incorporated.

GIS multicriteria decision analysis GIS-MCDA consists of a method to convert and combine spatial data/geographical information and decision-makers' criteria to attain evidence for a decision-making process. GIS capabilities are enhanced by MCDA procedures, techniques and algorithms for structuring decision problems, design, evaluate and prioritize alternatives.

The general data dimensions specified were the following:

1. Infrastructure:
    a. ports
    b. electricity grid or average lights
    c. railways, primary and secondary road network
    d. waterways

2. Access to IT:
3. Access to finance:
    a. bank locations
4. Market access:
    a. cities and travelling time to cities
5. Population and other socioeconomic information:
    a. Population density
    b. Socioeconomic information.
6. Production dimension (commodity or groups of commodities).

The analysis is developed for each product, commodity, or groups of commodities, by integrating the maps (layers of information). The layers support assessing suitable locations for storage and processing units in relation with prompt timing to transport food to downstream links of the chain and markets, and so must be:

- Connected with transportation infrastructure (roads, railways, airports, seaports, waterways)
- With access to:
    - energy (electric grid)
    - communications (mobile broadband coverage)
    - finance (banking locations).
- In production areas or regions.
- In regions with high poverty incidence.

Data on energy, communications or finance access might not be available for all Hand-in-Hand countries.

Two major processing steps lead to the final recommended locations or sites:

Step 1: Location Score - Overlaying the diverse layers (factors or criteria) a score is estimated, theoretically varying from 0 minimum, to 100 maximum.

The score is obtained by means of a simple weighted sum of layers (factors, criteria), e.g.:

*("Crop Production" * 0.4) + ("Human Population Density" * 0.2) + ("Major Cities Accessibility" * 0.1) + ("Regional Cities Accessibility" * 0.1) + ("Ports Accessibility" * 0.1) + ("Asset Wealth Index" * 0.1)*

Different weighting and criteria might be used for distinct value chains and agroecological zones, but also according to country data availability.

An example of the weighting for each of the criteria for livestock and dairy products can be as follows:

*("Crop Production" * 0.3) + ("Human Population Density" * 0.1) + ("Major Cities Accessibility" *0.2) + ("Livestock Intensification" * 0.4)*

The livestock intensification layer is created using animal density and livestock production systems (Robinson et al., 2011).[4] The selected livestock production systems vary from country to country, depending on existing agroecological zones.

All data layers are normalized, ranging from 0 to 100. A higher number indicates higher production or population density, but accessibility layers are inversely normalized, higher numbers indicate higher accessibility, lower travel time or cost.

The location score map output is a raster grid covering the country with a value for each cell (pixel).

Step 2: Final Recommended Locations - Top score areas are selected using a high percentile threshold, and then final locations selected overlaying financial services (bank buffer distance), mobile broadband internet coverage and maximum distance to a major road. It is noted that, some highly productive areas might not be recommended locations lacking good cellular coverage, being distant to banks or major roads, but in some cases by a very short distance.

A full adoption of the multi-criteria decision analysis methodology can lead to re-running and recalculating both the location score and final location, the modelling can be used as a what-if scenario tool, generating as many different outputs as the defined thresholds, helping to refine areas and enhancing the location decision-process communication. The analysis results and further links to all metadata, data and methodology are presented in the Appendix B.

[4] Example of selected Livestock Production System (Country_LPS) = (7: MR Mixed Rainfed Humid) + (8: MR Mixed Rainfed Temperate) + (9: MI Mixed Irrigated Hyperarid) + (10 = MI Mixed Irrigated Arid) + (11: MI Mixed Irrigated Humid) + (12: MI Mixed Irrigated Temperate) + (13: Urban).

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7. Appendix A – Description of the methodology

Central to the implementation of this methodology as originally conceived by Maruyama *et al.* (2018), however, is the availability of household-level survey data, including information on output prices and other household-level characteristics. Unfortunately, recent and high-quality household-level surveys are not available in several HiH countries, including some priority and fast-track HiH countries. Therefore, for FAO to carry out a similar analysis in these countries, alternative methods have been developed.

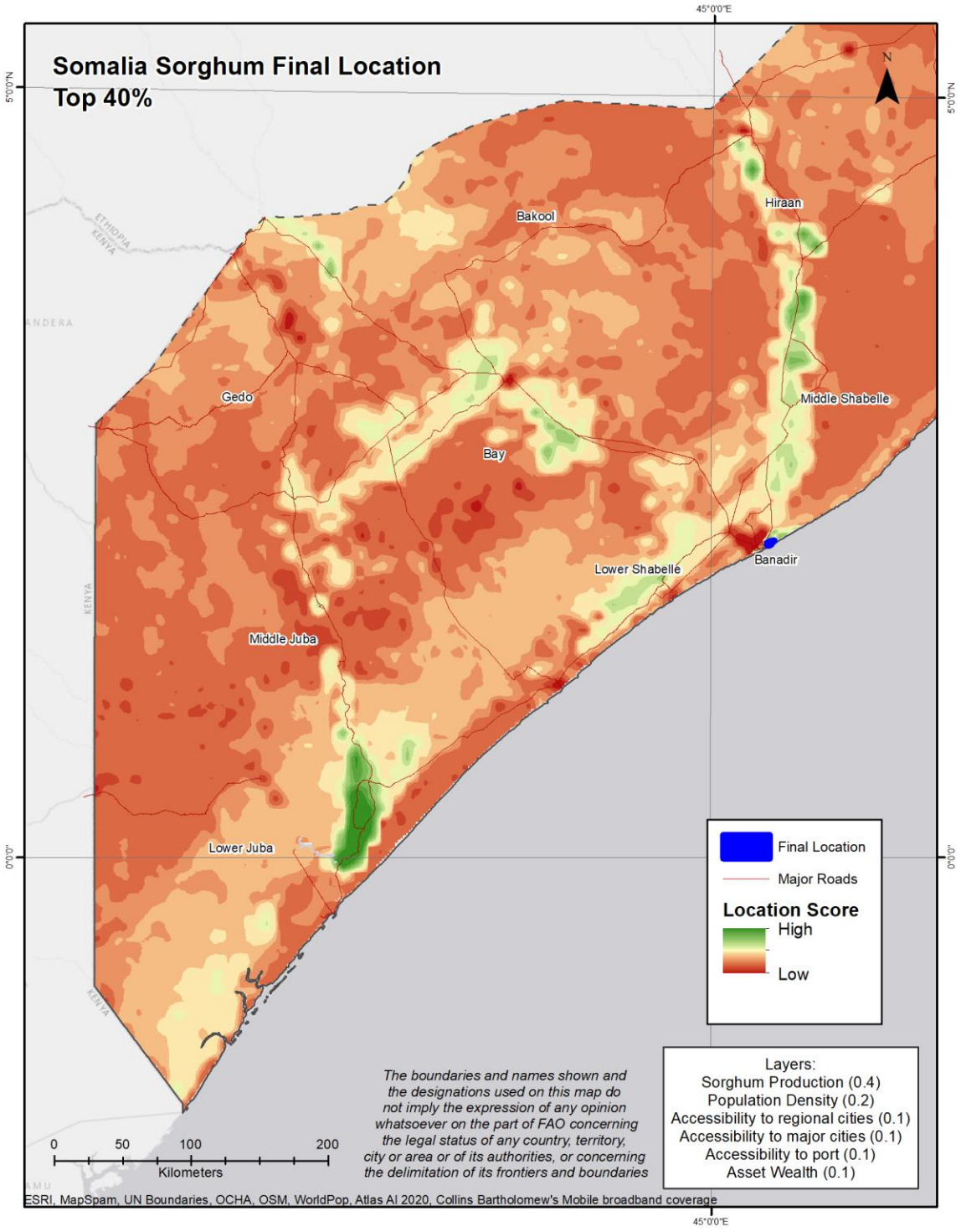
As Somalia is a crucial country, a new approach was implemented to calculate the agricultural potential and technical efficiency, that along with poverty, build the agricultural typologies. The approach is based on a Stochastic Frontier Model and combines macro- and meso-level data to obtain the typologies. The main idea behind this first approach is to estimate frontier and inefficiency equations at the national level (using a panel of countries) and then extrapolate this statistical relationship at the subnational level.

Given that market profits of individual farmers are not observable at the macro-level, we focus on the closest national-level equivalent to a profit variable, which is the agricultural value (per hectare). Since there are insufficient observations for each individual country to derive the statistical relationship to be extrapolated at the meso level, we use a panel of countries in the region of interest (in Africa, in this case) to derive the statistical relationships.

Using agricultural value per hectare as the main outcome of interest, we then estimate the statistical relationships using stochastic frontier models. Potential is a function of prices, long-term climatic conditions, and land-uses. In addition to these variables, we also add variables that proxy potential yields and livestock densities which allows to increase the spatial variation. As determinants of inefficiency, since household level data is not available, we focus merely on yield gaps, inefficiencies in livestock densities, weather shocks, and access to markets.

8. Appendix B – GIS-MCDA Final Location Mapping outputs

Figure 10: Crop Storage Final locations



Metadata, data and resources: https://data.apps.fao.org/catalog/organization/hand-in-hand

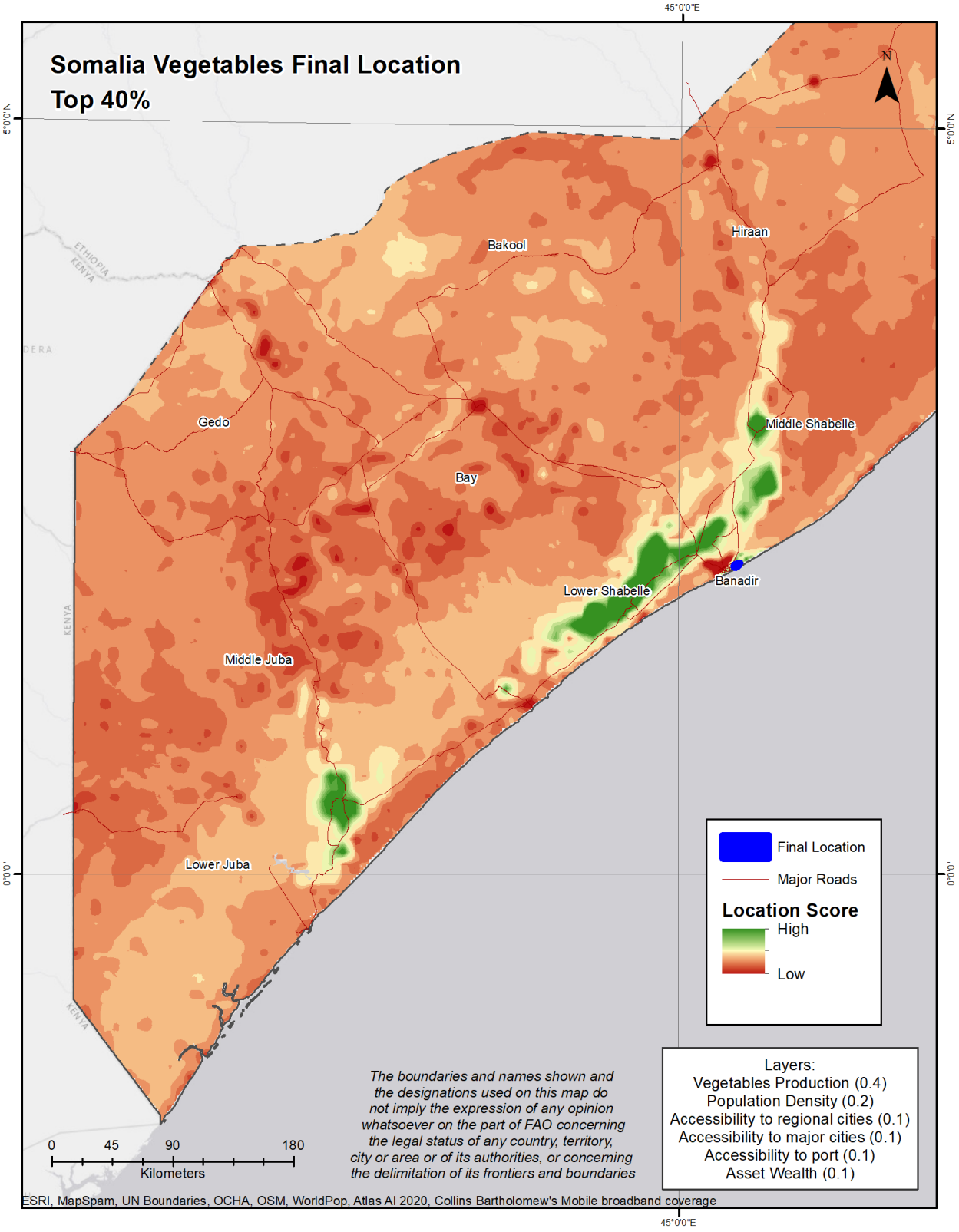
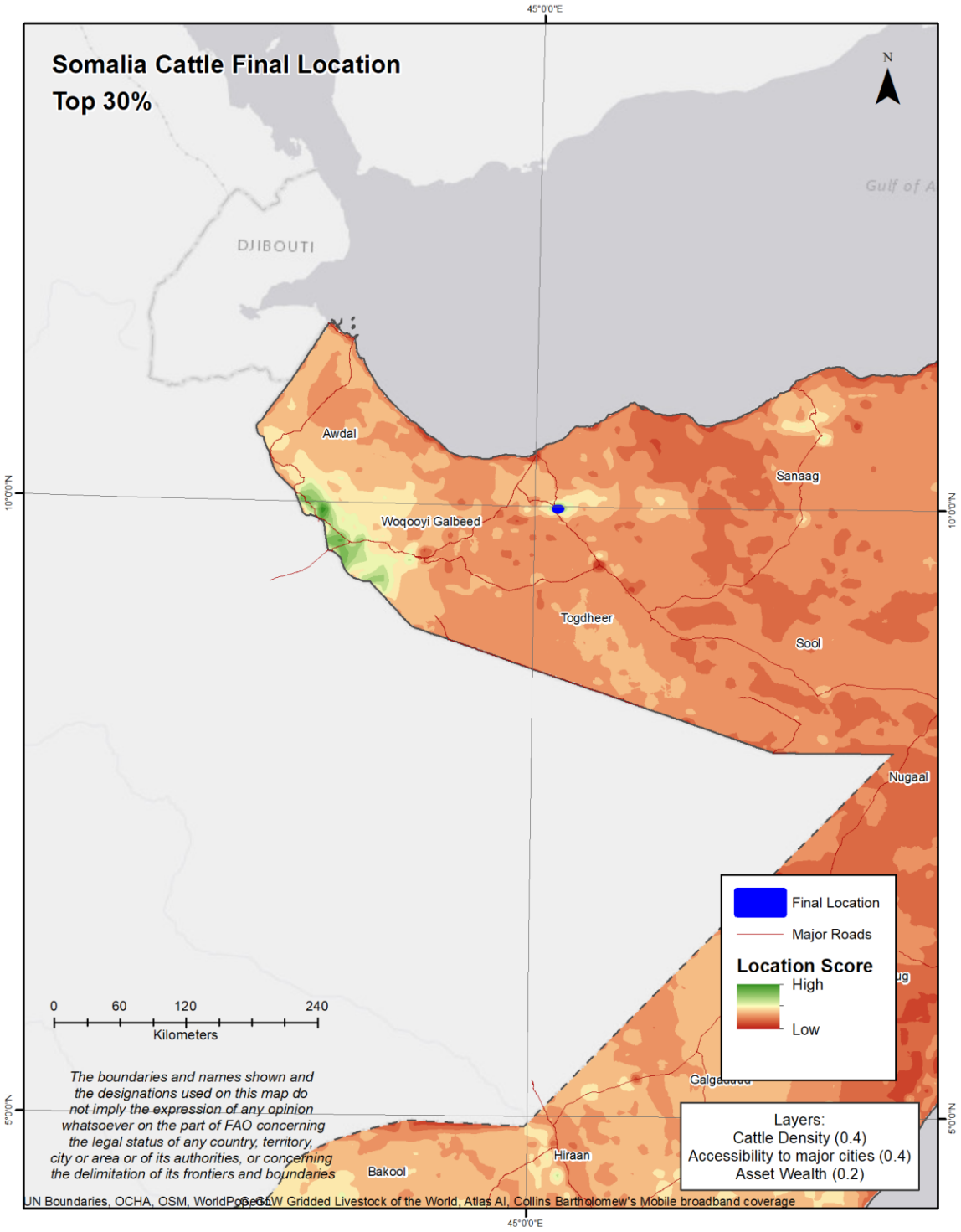

Somalia Vegetables Final Location
Top 40%
45°0'0"E
5°0'0"N
0°0'0"
N
Bakool
Hiraan
Gedo
Bay
Middle Shabelle
Banadir
Lower Shabelle
Middle Juba
Lower Juba
ETHIOPIA
KENYA
Final Location
Major Roads
Location Score
High
Low
0
45
90
180
Kilometers
The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries
Layers:
Vegetables Production (0.4)
Population Density (0.2)
Accessibility to regional cities (0.1)
Accessibility to major cities (0.1)
Accessibility to port (0.1)
Asset Wealth (0.1)
ESRI, MapSpam, UN Boundaries, OCHA, OSM, WorldPop, Atlas AI 2020, Collins Bartholomew's Mobile broadband coverage

Figure 11: Dairy Processing Units Final Location



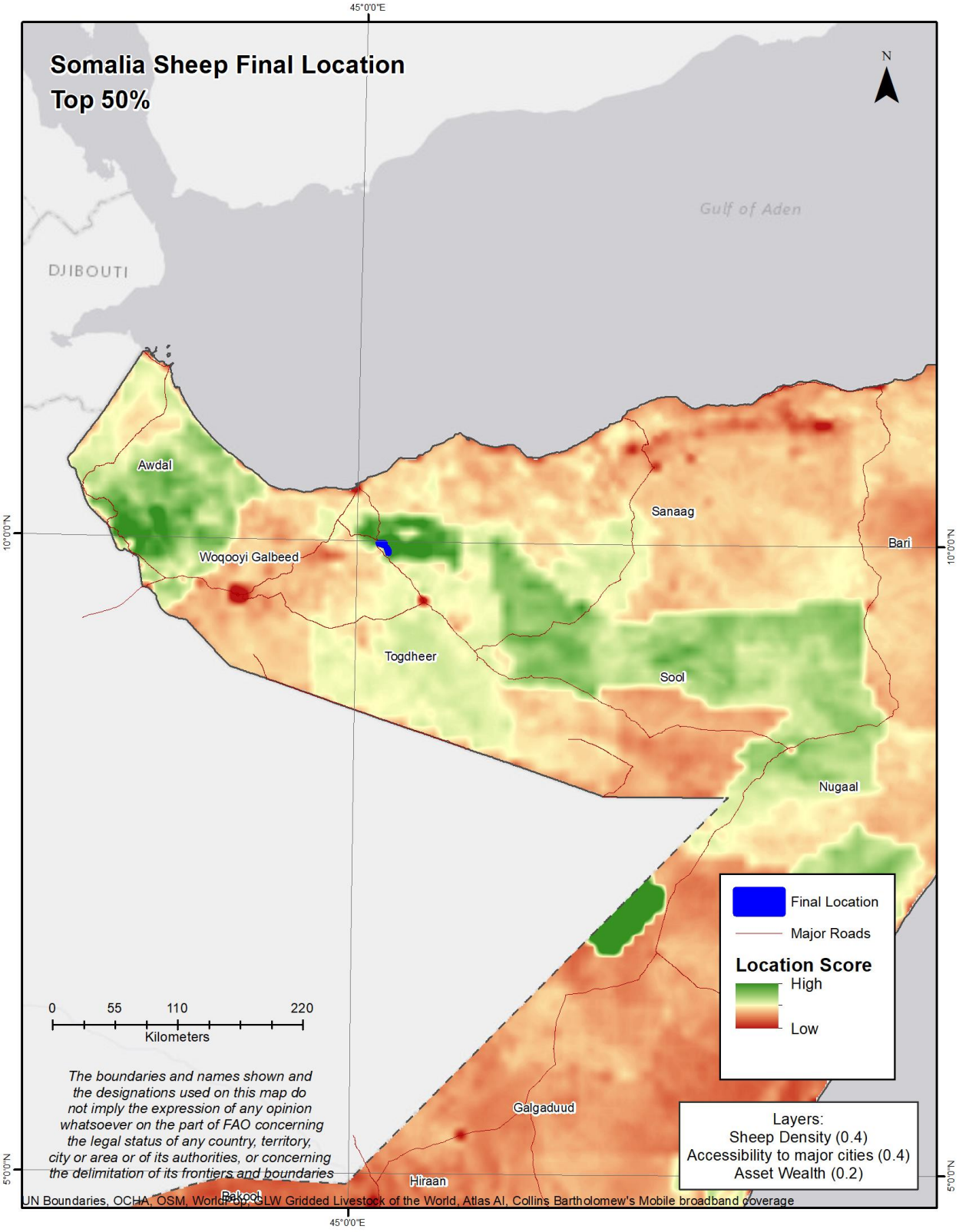
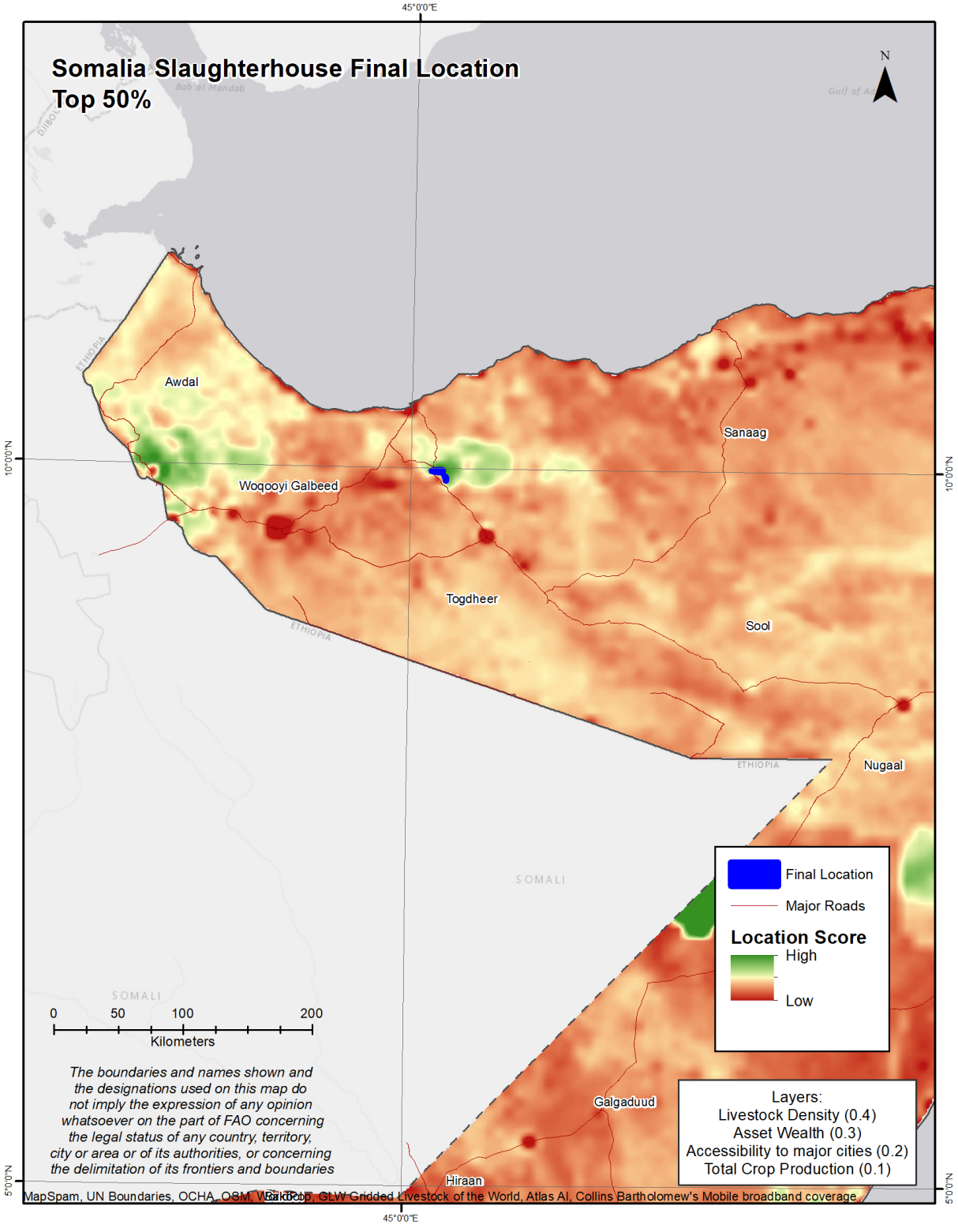

Somalia Sheep Final Location
Top 50%
N
Gulf of Aden
DJIBOUTI
Awdal
Woqooyi Galbeed
Sanaag
Bari
Togdheer
Sool
Nugaal
Galgaduud
Hiraan
Bakool
45°0'0"E
10°0'0"N
5°0'0"N
Final Location
Major Roads
Location Score
High
Low
0 55 110 220
Kilometers
The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries
Layers:
Sheep Density (0.4)
Accessibility to major cities (0.4)
Asset Wealth (0.2)
UN Boundaries, OCHA, OSM, World Bp, GLW Gridded Livestock of the World, Atlas AI, Collins Bartholomew's Mobile broadband coverage

Figure 12: Slaughterhouses Final Location



Source: FAO-HiH GIS team (2024)