Yield potential and gap analysis of maize production in Sulawesi, Indonesia

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Abstract. Maize production in Indonesia is not stable, especially in areas of Sulawesi. Production and productivity achieved at the farmer level fluctuates and are still very low, so that a yield gap exists between yield achieved and yield potential. Based on time series data for 7 years (2001-2007), it was indicated that the average production and productivity vareid greatly, i.e: in North Sulawesi the average production was 200,985 t with productivity of 2.57 t/ha, in Central Sulawesi production was 64,664 tons with productivity of 2.45 t/ha, in South Sulawesi production was 698,198 tons with productivity of 3.26 t/ha, in Southeast Sulawesi production was 77,023 tons with productivy of 2.21 t/ha, and in Gorontalo production was 297,990 tons with productivity of 3.39 t/ha. Across Sulawesi, the average annual production was 1,338,862 tons with productivity of 2.78 t/ha. Thus, maize productivity in Sulawesi was still very low compared with yield potential and average yield of several superior varieties, both hybrid and composite, such that a 3-6.5 t/ha yield gap occurred. This yield gap could be overcome by the availability of a packet of locally specific planting technologies that could be easily and quickly adopted by farmers.

Key words: production, productivy and yield gap.

Introduction

In the regional development of agriculture, maize is a secondary crop after rice, and is mainly planted in the rainy season on dry fields and to a lesser extent during the dry season.

Growth rates in various regions are very different, and there is a prosperity gap in the society of every region. These differences are due, for instance, to differences in income across society, provided socio and economic infrastructure, and ownership of resources. Regional development is intended to equalize the distribution, it means that participatory planning and society involvement in all regions in the provincial development process to improve the strength of growth capacity in the region of a province, and also able to encourage the development of other provinces that are relatively less developed. It is necessary to increase the cooperation amongst provinces, and for producers and development efforts to be coordinated to benefit regional development.

Sulawesi, regionally, consists of five provinces, one of which is a very young province with different potential, particularly in agriculture and especially for maize.

There are two types of approached to regional development: sectoral and regional (Yusuf G, 1999). The sectoral approach is initiated with some questions: 1) Which sector must be improved to handle national development, 2) For each produced material, how is it produced, what technology is needed, and when it is produced, 3) When will the sector activity occur, 4) What policy, strategy and steps must be taken? Meanwhile, the regional approach focuses on the question, which region should receive the priority for improved, and what sector is most suitable to achieve improvement in region's society?

One of the regional approach policies supports the national program to production 2000 million tons of maize can be seen from the potential data in each region, particularly the capacity of the land, production, and productivity then. It can then be seen that there is a gap resulting from differences in natural resources, soil, climate/season, the availability of water, human resources, technology, technology adoption and management, and a number of problems in the region.

Based on the explanation above, it is necessary to know the yield potential of maize and the gap that occurs in farmers' fields, with the result of this research identifying the causal factors of the yield gap and how to handle them.

Methodology

The research was held by collecting data for the time series from 2001-2007 in five provinces in Sulawesi: South Sulawesi, North Sulawesi, Central Sulawesi, South East Sulawesi, and Gorontalo. The data were taken from BPS Indonesia and Gorontalo, Seed Certification Bureau of South Sulawesi, ICER, and other tabulated information. The collected data comprised: harvested area, production, seed distribution and productivity. The data were analyzed using tabular and descriptive methods.

Result and Discussion

General Potential of the Region

The landmass of Sulawesi is approximately 190-405 km^2, the largest province is South Sulawesi: 67,960 km^2, and the smallest one is Gorontalo: 12,214.44 km^2.

Of the total landmass, lands are used for yard, garden/ field, meadow, fishpond, state garden, field, and some is not used. Some of the land is used for food plants, particularly maize on 889,852 ha after rice and a secondary maize crop in rainy season on 1,711,251 ha.

Harvested Maize Area

The maize area in Sulawesi region, based on 2001-2007 data, was approximately 429,913.86 ha. The largest area is in South Sulawesi, followed by North Sulawesi, Gorontalo, South East Sulawesi and the smallest area is in Central Sulawesi. This can be seen in Table 1, which shows that the extent of harvested area in Sulawesi region increased with a growth rate of 9.35%; the highest rate was in Gorontalo, followed by Central Sulawesi, North Sulawesi, South East Sulawesi, and the smallest was in South Sulawesi. This shows that Gorontalo is the province with most rapid growth in maize area.

Maize Production

Based on the data for 2001-2007, the maize production in Sulawesi region always increased year by year, with an average production of 1,338,862.14 tons. The greatest maize production was obtained in South Sulawesi, followed by Gorontalo, North Sulawesi, South East Sulawesi, and the least was in Central Sulawesi (Table 2).

Table 1. The Harvest Area of Maize in Sulawesi Region, 2001 – 2007

No	Year	Harvested Area (ha)					Sulawesi Region
		North Sulawesi	Central Sulawesi	South Sulawesi	Southeast Sulawesi	Gorontalo	
1	2001	68443	20330	191960	28771	36610	346114
2	2002	55659	21850	205909	33789	45718	362925
3	2003	65656	22309	213818	37927	58716	398426
4	2004	66250	22657	199310	35827	60773	384817
5	2005	88854	26553	210336	32658	88376	446777
6	2006	82189	25587	206387	33343	109792	457298
7	2007	115664	40371	262214	40975	118816	578040
Average		77531	25665	212848	34756	74114	424914
Growth Rate (%)		11.26	13.75	5.84	6.71	22.45	9.35

Sources: BPS, Statistik Indonesia (2002, 2005 dan 2008), BPS, Statistik of Gorontalo Provence, 2002 and Gorontalo in Figures 2008

Table 2. The Maize Production in Sulawesi Region, 2001 – 2007

No	Years	Production (ton)					Sulawesi Region
		North Sulawesi	Central Sulawesi	South Sulawesi	Southeast Sulawesi	Gorontalo	
1	2001	150459	49095	515405	60358	131420	906737
2	2002	116867	48498	661005	68148	130251	1024769
3	2003	144668	49177	650832	87650	183998	1116325
4	2004	150124	53450	674716	78147	251214	1207651
5	2005	195305	67101	719139	73154	400046	1454745
6	2006	242714	66433	696984	74672	416222	1497025
7	2007	406759	118897	969306	97037	572784	2164783
Average		200985	64664.4	698198	77023.7	297990.714	1338862.14
Growth Rate(%)		3.53	3.12	2.03	1.56	4.94	2.72

Sources: BPS, Statistik Indonesia (2002, 2005 dan 2008), BPS, Statistik of Gorontalo Provence, 2002 and Gorontalo in Figures 2008

Tabel 3. Maize Productivity in the Sulawesi Region, 2001-2007

No	Years	Productivities (ton/ha)					Sulawesi Region
		North Sulawesi	Central Sulawesi	South Sulawesi	Southeast Sulawesi	Gorontalo	
1	2001	2.19	2.41	2.68	2.10	2.23	2.32
2	2002	2.10	2.22	3.21	2.02	2.85	2.48
3	2003	2.20	2.20	3.04	2.31	3.13	2.58
4	2004	2.27	2.41	3.44	2.22	3.46	2.76
5	2005	2.72	2.52	3.42	2.24	3.51	2.88
6	2006	3.00	2.59	3.33	2.24	3.70	2.96
7	2007	3.51	2.94	3.69	2.37	4.81	3.47
Average		2.57	2.45	3.26	2.21	3.39	2.78
Growth Rate		1.42	0.60	0.98	0.37	2.36	1.16

Sources: BPS, Statistik Indonesia (2002, 2005 dan 2008), BPS, Statistik of Gorontalo Provence, 2002 and Gorontalo in Figures 2008

Maize Productivity

Maize productivity in the Sulawesi region always increased based on the data for 2001-2007, and averaged approximately 2.78 t/ha. The highest productivity was in Gorontalo; with 3.39 t/ha, followed by South Sulawesi (3.26 t/ha), North Sulawesi (2.57 t/ha), Central Sulawesi (2.45 t/ha), and the lowest was in Southeast Sulawesi (2.21 t/ha), as seen in Table 3.

From Table 3 it can be seen that the average productivity growth rate in the Sulawesi region was approximately 1.16% per year. Among the five provinces, the highest productivity growth rate was in Gorontalo (2.36%), followed by North Sulawesi (1.42%), South Sulawesi (0.98%), Central Sulawesi (0.60%) and the slowest growth was in Southeast Sulawesi (0.37% per year).

Table 4. OVP Improved Varieties Released Since 1980 by IAARD

No	Varieties	Years Released	Yield potential (t/ha)	Productivity (t/ha)
1	Arjuna	1980	-	4.3
2	Bisma	1995	7.5	5.7
3	Gumarang	2000	8.0	5.0
4	Kresna	2000	7.0	5.2
5	Lamuru	2000	7.6	5.6
6	Sukmaraga	2003	8.5	6.0
7	Srikandi Kuning	2004	7.9	5.4
8	Srikandi Putih	2004	8.1	5.9
9	Arjuna	2006	6.6	4.6

Sources: BPS, Statistik Indonesia (2002, 2005 dan 2008), BPS, Statistik of Gorontalo Provence, 2002 and Gorontalo in Figures 2008

Yield Gap

The 2001-2007 data show that maize productivity remains much lower in farmers' fields (Table 3) than the yield potential determined in several multi location tests by the Indonesian Agency for Agricultural Research and Development (IAARD) (Table 4). IAARD has released a total of 63 high yielding varieties, both OPV's and hybrids. In 2008, the planted area for maize in Indonesia was covered 43.7% with hybrids, 30.0% with composites and 26.3% with local varieties (ICER, 2008)

The yield gap is caused by several constraints, including: 1. Biophysical constraints, 2. Economic and Socio-cultural constraints, and 3. Institutional constraints.

Biophysical constraints comprise: Biotic constraints (pests, diseases and weeds) and abiotic constraints (soil fertility, drought, floods, etc.)

The most frequent constraints to maize growth are pests and diseases either in the field or in storage. The loss of yield caused by pests varies from 20-80% (Baco et al, 1983) and the damage caused by *downy mildew disease* can reach 100% (Sudjono, 1988), spoiled stalks 50% (Shurtleff, 1980). Generally, maize planting in particular months is often attacked by pests, for instance in May-August corn borer (*Ostrinia furnacalis*), October-March corn ear worm (*Helicoverpa armigera*) and April-September army worm (*Spodoptera sp).*

Maize varieties that are resistant to *downy mildew*, *ear rot*, and *sheath blight* have been known (Wakman et.al, 2001; Wakman and Hasanuddin, 2004); nonetheless, not all farmers plant such varieties. Also, there are many maize varieties released recently for which their resistance against pests and diseases in unknown.

The most common abiotic constraint is drought, which is caused by poor temporal distribution of rain. Yield decrease occurs if drought occurs during the reproductive phase, particularly on annual planting pattern: Rice – Palawija is very risky because of the lesser availability of plants, especially maize.

Socio Cultural and Economic Constraints

Maize production and productivity in farmers' fields is still much lower than the yield potential for several varieties released by ICER because of the use of poor production facilities; and failure to use high quality seed, fertilizer, herbicide and pesticides according to recommendations. This is caused by expensive input prices and limited farmers' capital and knowledge. Moreover, from the social and cultural perspectives, the ownership of land is narrow and widespread, and most farmers do not own the land, so they are very dependent on the owner of the land. Besides, labor is expensive and quality of education is poor, so the mastery of knowledge and technology affects the technology adoption.

Institutional Constraints

Economic organizations in the rural region are often lacking or distant. This makes it difficult for farmers to obtain production facilities and working-capital. Therefore, it is necessary to establish credit organizations and production facility stores in every village, where these are easily reachable by the farmers. It is necessary to form or activate farmer groups and extension services in delivering technologies, so that farmers can easily adopt and apply technologies to increase their production and income, and create a prosperous society.

Conclusion and Suggestions

1. Global maize production has risen in Sulawesi, despite fluctuations during the seven years 2001-2007.
2. The increase in harvested area, production and productivity of maize has the greatest potential in Gorontalo among all Sulawesi Provinces.
3. In general, there remains a large yield gap between farm level yields and yield potential for several varieties both composites and hybrids.
4. The constraints to production include biophysical, economic, socio-cultural, and institutional (e.g. extension services, etc).
5. Cooperative research and development should be conducted on Zea mays production and utilization.
6. Efficient databases should be developed to facilitate the sharing of information.

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